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JOURNAL OF THE ROYAL STATISTICAL SOCIETY

VOL. 115
1952

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JOURNAL

OF THE

ROYAL

STATISTICAL SOCIETY

SERIES A (GENERAL)

110633
CHECKED 1973
Initials

Founded 1834

Incorporated by Royal Charter 1887

Vol. CXV—1952

LONDON:
ROYAL STATISTICAL SOCIETY
4, PORTUGAL STREET, W.C.2

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Journal of the Royal Statistical Society
SERIES A (GENERAL)
PART I, 1952

THE ECONOMETRICS OF FAMILY BUDGETS

By H. S. HOUTHAKKER

University of Cambridge, Department of Applied Economics

[Read before the ROYAL STATISTICAL SOCIETY, November 28th, 1951, The President, Professor A. BRADFORD HILL, C.B.E., in the Chair]

Family budgets have been frequently discussed by the Society or in its Journal, and it is therefore unnecessary to stress here the great contribution they can make to our knowledge of the basic facts of economics. In recent years there have been Mr. Massey's report on the survey of certain groups of middle-class households which he directed in 1938–39 (Massey, 1942), Mrs. Ross's detailed calculations on the clothing consumption of a sample of families from the 1937–38 working-class inquiry (Ross, 1948), and Mr. Nicholson's more comprehensive researches into the expenditure of another group of families from that inquiry (Nicholson, 1949). Elsewhere Professor A. M. Henderson (1949–50) has given estimates of the "cost of children" based on both the pre-war surveys. The Ministry of Labour, which at first had published only a few overall averages for their 1937–38 survey (Ministry of Labour, 1940, 1941), recently made available a classification of expenditures by region and by total expenditure (Ministry of Labour, 1949). Stuvel and James (1950) investigated food expenditure in Dutch family budgets.

When early in 1950 an investigation into the current demand for foodstuffs was started at the Department of Applied Economics it was soon realized that the above publications, valuable though they were in themselves, did not exhaust the wide range of information which the 1937–38 working-class and the 1938–39 middle-class household surveys might be expected to yield. It was therefore decided to undertake a new analysis of the largest possible number of individual returns, transcripts of which the Ministry of Labour (acting also as custodian of the middle-class budgets) kindly put at the Department's disposal. In fact data for about 2,200 working-class households, all of whom supplied clothing information for a whole year, and for the entire sample of middle-class families analysed by Massey were available.* Practically all the information on these returns was punched on cards, and through the generous assistance of a number of organizations with Hollerith equipment (mainly Government Departments) the extensive task of tabulating the figures was made possible. Specific acknowledgments are given at the end of this paper.

The results of this work will be published in a forthcoming monograph of the Department of Applied Economics. The present paper should be regarded as a preface to the latter, setting out the intentions and methods of the analysis, illustrated where possible with numerical examples and dealing with some more general questions encountered in the investigation of household budgets and its application to specific economic problems. The subjects discussed will be found to be largely the same as in the pioneering monograph of Allen and Bowley (1935), which is still without rival as an introduction to the theory and econometrics of this field, though naturally opinions have developed since its appearance and many of its conclusions can no longer be upheld.

* The number of working-class budgets was slightly less than that dealt with in Chapter VI of (Ministry of Labour, 1949) as some forms were unusable. On the other hand, there was one more middle-class budget (making 1,361 families in all) than the number with which Massey worked.

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Apart from some incidental remarks we shall not discuss the design of household surveys, but only the analysis of the results, especially the econometric analysis which is intended to isolate and measure the regularities of an economic nature by statistical methods. When regularities belong to economics and when they do not is a delicate point which may be evaded by quoting the convenient definition that "economics is what economists do". This will exclude most work on nutrition, the other main source of interest in family budgets. The application of family budgets to the construction of index numbers and to calculations on the burden of taxation cannot be discussed here either, though some of our remarks will be relevant to these subjects.

1. *The Theoretical Background*

1.0. According to economic theory the consumption of an individual will be determined by his income and the prices ruling on the market in conjunction with his preferences. This will incidentally apply to households only if a certain unanimity between the several persons normally constituting a household is postulated (cf. Samuelson (1950), pp. 374–5).

1.1. *Income* is of course the most obvious cause of differences between the consumptions of different families, and indeed the central factor in all budget analyses. In practice it is often difficult to ascertain, and in any case its influence may be lagged (cf. Tobin (1950), pp. 115–7), so that one may have to work with total expenditure instead, as is done in the present analysis. The gain in statistical precision probably outweighs any theoretical difficulties this may cause; it might even be argued that total expenditure fits much better into a theoretical scheme which effectively ignores savings. Some calculations on the relation between income and total expenditure are given in section 8 below.

1.2.0. One of the assumptions commonly used in estimating the effect of income on consumption is that *prices* are the same for all families in a survey. This may be substantially true for most commodities, but for some items, particularly rent, it is frequently not true; because of income effects this may significantly affect all other items of expenditure (cf. Section 6). Differences in rent are probably an important cause of geographical variations in consumption, especially between localities of different sizes, but in practice they need not always show up because of randomization. Only where the level of rents is correlated with the level of incomes may these regional differences become a source of bias.

1.2.1. Other differences in prices arise when consumers can obtain reductions for large purchases (e.g., block tariffs for gas and electricity); it will be very difficult to allow for this. Falling average prices per unit under two-part tariffs are another matter, however, since only the fixed charge and the marginal price are relevant (cf. Houthakker (1951), p. 360).

1.2.2. Apparent differences in prices may occur if goods are available in a variety of qualities, but this difficulty results only from the necessarily incomplete classification of goods, and does not violate the hypothesis of equal prices for the same item of consumption. It points to an interesting subject of inquiry (cf. Section 4 below).

1.3.0. Variations in *preferences* will also have to be taken into account if one wants to establish a justifiable method of drawing general conclusions from a sample of families; differences in income and prices will never be sufficient by themselves to explain the wide scatter that is found. Such variations should not only be studied because they may bias the estimates of income effects, for they also raise some remarkable problems of their own. The most tractable variations are naturally those that can be associated with observable exogenous factors, while the remainder must be assumed to lead to a probability distribution of some form.

1.3.1. The effect of variations in tastes can only be observed indirectly, viz., from consumption, on which they have a twofold effect. If, for instance, a man decides to keep a cat (*ceteris paribus*) his demand for milk will increase (a *specific effect*), but in order to pay for this he will have to spend less on other goods, which will therefore experience an *income effect*. This distinction is analogous to that between substitution effects and income effects expressed in the Slutsky-Hicks equation (Hicks, 1939, p. 309), which has recently also been interpreted in terms of changes in tastes (Ichimura, 1950–51; Hicks, 1950–51).

1.3.2. The demand for food, clothing, education, etc., evidently depends on the age and sex composition of a family, and since these items have a large share in total expenditure, the resulting specific effects will be accompanied by considerable income effects. Here we have in fact the

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most important form of variations in preferences. It should be noted that the specific and the income effects work in opposite directions (except in the case of inferior commodities), for at constant income their algebraic sum over all goods (in money terms) must be zero. Thus a large family which would like to spend more on clothing than a smaller one with the same income may in fact have to spend less because it also has to pay for more food. From this it can further be seen that the total effect of differences in family composition on the consumption of a good will in general depend on income, for whereas the specific effect may remain the same, the income effect is spread out over a larger range of commodities if income is high. A more detailed discussion of the family size problem will be found in Section 5.

1.3.3. The occupations of the members of the household will also influence the demand for various goods. In so far as this influence is of a technical nature (e.g., the fact that heavy manual labour will require much food) it is questionable whether this can be described as a variation in preferences at all; indeed the same thing might be asked about the social conventions which cause middle and working-class households to consume different amounts even though their incomes and other circumstances are the same. The difficulty is still more apparent where relatively many members of the family are at work so that they have to hire domestic help or buy more prepared food. For our present purpose it will be difficult to do anything but describe these differences to varying preferences, though an analysis embracing both consumption and employment might explain them as ultimately due to different abilities and opportunities. In the same way regional variations in consumption patterns (if not due to differences in prices, cf. 1.2.0) may perhaps also be reduced to differences of circumstances.

1.3.4. Family size, occupation and location are no doubt the three main factors on the preference side which make for differences in consumption. We have said already that any other factors will in practice have to be lumped together in a probability distribution of the residuals from some appropriate regression. The question then arises what form this distribution will have. It would be convenient to have a homoscedastic normal distribution, and Allen and Bowley (1935, pp. 140–1) have given reasons why this might in fact be found, but their argument is not convincing since they ignore the fact that consumption cannot be negative (cf. 3.3). It seems probable, if one takes this fact into account, that the distribution is skew (with the median smaller than the mean), and that the variance will increase when income rises as there will then be more scope for variations of taste, income effects being less serious (cf. 3.5).

2. *Objectives of the Analysis*

2.0. The theoretical considerations just outlined provide general directives for the new analysis of the budgets described in the introduction. Our principal intention was to get reliable estimates of the effect of income on consumption, for which purpose the sources of bias we have described had to be eliminated as far as the basic data would allow.

2.1. One classification was available at once, viz. between working-class households (where the head was a non-agricultural worker earning less than £250 a year) and middle-class households (where the head was a civil servant, local government official or teacher earning more than £250 a year). The design of the middle-class inquiry was aimed at comparability with the working-class survey: both referred to four weeks at quarterly intervals during the year (except for clothing, for which a number of families supplied information during 48 weeks), the periods during which they were held overlapped, and the commodity classification was substantially, but not completely, the same (cf. also Henderson, 1949). The presentation of the results in (Massey, 1942) and (Ministry of Labour, 1949) was not consistent, however, and in any case insufficient, as we shall explain. As the detection of social class differences in consumption (cf. 1.3.3) was one of the objectives of our inquiry a uniform treatment of the two groups of budgets was necessary.

2.2. In Mr. Massey's paper the families were classified by the yearly income of the head as stated during the first week of the inquiry. No income figures for the working-class households were available, so this criterion could not be adopted. In Chapter VI of (Ministry of Labour, 1949), which refers to the working-class budgets here analysed, the basis of classification was average total expenditure during the four weeks of the inquiry, except for clothing, where the average over 48 weeks was used. The latter correction could not be applied to the middle-class

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budgets, only part of which contained continuous clothing information. The reason for the Ministry's adjustment was no doubt the erratic behaviour of clothing purchases from week to week, but this occurs also in many other items, and the chance that these random deviations (which will be negatively correlated) cancel out is obviously greater if no separate adjustments are made. The criterion finally adopted was *expenditure on all items during the four weeks of the inquiry*.

2.3.0. A classification by total expenditure only is in general not sufficient to remove the disturbances mentioned in 1.3 above. It is usually found that family size is positively correlated with total expenditure, at any rate within one social class, the reason being that large families usually contain several earners. The two inquiries under consideration are both striking illustrations of this tendency, and attempts to calculate income elasticities from the figures in Chapter VI of (Ministry of Labour, 1949) are therefore doomed to failure. The same applies to the classification by income of the head of the household used by Massey (1942); in that group of the population income rises with age and so does, broadly speaking, the number of children and their age. *Hence it is essential to classify families by income (or total expenditure) and family size simultaneously;* because of the correlation just indicated two one-way classifications will not suffice.

2.3.1. The conclusion in italics will seem trivial to those with experience in family budget analysis; nevertheless it is emphasized in view of current preparations for a new budget survey in Britain. It is much better to have a sample of manageable size that can be properly analysed (about 5,000 should be ample to get reasonable cell-frequencies), than one which is so large and costly as regards fieldwork that only part of the available information can be extracted. The contribution of a second lot of 5,000 budgets to the precision of an over-all average would be negligible; it could only be justified by the additional cross-classifications it makes possible.

2.3.2. A two-way classification as required was used by Nicholson (1949) and Henderson (1949, 1950), but not for detailed items of expenditure. Moreover, both these authors were especially interested in the effect of children on consumption, and consequently confined themselves to a much smaller number of budgets than could be investigated here. Some calculations on the material used by Nicholson are given in Table 1.

2.3.3. The simplest basis for grouping families by their composition is the number of persons, which has been used here. It has the advantage of being determinate in advance, unlike "family types" or the number of "unit consumers" (cf. Section 5), although the latter may give more precise groupings (i.e., a smaller variance within groups) after they have been agreed on.

2.4. Regional variations are probably a less serious source of bias than family size; in any case a complete analysis of this factor was impossible, because the middle-class budgets did not indicate the location of the household. In the punching of the working-class budgets the possibility of regional analyses was taken into account, but in this paper we shall only present some calculations on differences due to living in London (cf. Section 6).

2.5. We have already mentioned the problem of qualities (1.2.2)—a very important one for the combination of time series and family budgets in demand analysis (cf. Tobin (1950), especially pp. 147–8), as the former usually refer to some kind of physical measure and the latter usually to money expenditure. Since changes in income and family size will lead to shifts between more and less expensive qualities of a good the behaviour of quantity and expenditure will diverge. For the working-class households quantity figures in respect of a number of commodities, mainly foodstuffs, were available on the documents. They were not always complete, however, and had not been analysed previously. Special precautions in the tabulation of the punched cards made it possible to calculate the average prices per unit paid in the various income-size groups. This information proved to be of great interest, not only because of its relevance to demand analysis, but also because of its possible application to the problem of family size influences (cf. 5.4.3).

2.7. At the time when the analysis was started it was also believed that the intercorrelations between different items of expenditure, after correction for income, etc. (cf. Allen and Bowley (1935), pp. 89–96), might lead to estimates of the substitution effects between them, thus providing estimates of cross-price elasticities where time series methods failed. Further theoretical research revealed, however, that although these intercorrelations are closely related to the cross-price elasticities, the mathematical link between them is such that no useful estimates can be obtained.

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2.8. To sum up, the main features of our analysis are:

a. Two-way classification by total expenditure and by number of persons in the household.

b. Uniform treatment of working and middle-class households, with subsequent comparisons between them.

c. An investigation of average prices, with application to family size problems.

Moreover the tables in the monograph will show not only average expenditure by each group of families, but also the number of households who reported having bought something. The commodity classification will be as detailed as possible.

3. *Engel Curves*

3.0. The investigation of the relation between income (or total expenditure) and the expenditure on particular items or groups of items, represented by so-called Engel curves, is still the most important function of family budgets in econometrics. In practice its discussion cannot be divorced from the questions of family composition, social differences and regional variations that will be dealt with below, nor would it be advisable to discuss these questions first; some anticipations of later remarks are therefore inevitable. We do not propose to speak here of the interpretation of Engel curves as short or long run phenomena and similar problems; our topic is how to derive meaningful, accurate and comprehensive descriptions of the regularities that are apparent in the data.

3.1. It will be remembered that in Allen and Bowley's admirable *Family Expenditure* (1935) most of the income-expenditure relations investigated were found to approximate closely to straight lines. The same technique was applied by Allen (1942) to data for different "types" of families from the U.S. survey of 1935–6,* and by Henderson (1949) to British data; in both cases different straight lines were fitted for different family types. Nicholson (1949) introduced quadratic terms into the regression equations because of the curvilinearity which became evident when families were grouped both by total expenditure and by size.

3.2. These linear and quadratic functions (and more generally all polynomials) have the useful property, unlike other mathematical approximations, that the regressions for individual commodities add up identically to total expenditure (Nicholson (1949), pp. 388–9). On the other hand, the expenditures which they predict will be negative for some part of the positive income range, a defect that is not shared by some functions, such as the logarithmic ($\log y = a + b \log x$), that are excluded by the additivity condition. Another drawback of polynomial regression is that, unless the range of observation is much larger than is usual in budget surveys, the sampling covariance of the regression coefficients is frequently very high as a variable and its square will then be highly intercorrelated.

3.3. It might be thought that theoretical considerations would support polynomial regression because of its additivity. Thus Allen and Bowley (1935, pp. 135–7) have discussed how linear Engel curves fit into a simple but by no means trivial special case of consumption theory.† Unfortunately their argument cannot be accepted for the reason already mentioned, viz., that the essential non-negativity of consumption is ignored. As soon as the appropriate boundary conditions are introduced Engel curves turn out to be much more complicated functions of income, which show kinks at points where new goods enter the budget or others drop out.‡ It is a matter of theoretical indifference what analytical approximations are applied to the resulting theoretical Engel curves, which are continuous but not everywhere differentiable. Further difficulties are connected with the problem of allowing for random variations in preferences under these circumstances (it is one of the most valuable contributions of *Family Expenditure* to have introduced this problem into consumption theory). Nevertheless it may be expected that for most commodities, especially foodstuffs, the slope of the Engel curves will diminish as income rises, as room has to be made for goods that are only consumed after a certain income has been reached.

* The seven family types distinguished in that survey were based on the number of children and the number of adults.

† It appears, however, that quadratic Engel curves (or higher polynomials) cannot be derived from any explicit utility function.

‡ This will be more fully explained in Houthakker (1952).

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3.4. Strictly speaking there is no reason why the same type of function should be applicable to all commodities, but this is of course highly convenient from a computational point of view. In practice it is also desirable to use expressions that are amenable to maximum-likelihood estimation; graphical methods are too unreliable for anything but exploration, particularly when the observations have different weights. This rules out the formula suggested by Tornquist (1940), where the expenditure on an item is the ratio of two linear functions of total expenditure.

3.5. Statistical considerations should also have some influence on the choice of the regression function. In ordinary regression theory the residuals are assumed to be normally and independently distributed with constant variance. We have already expressed doubts on the normality and homoscedasticity of the expenditures (cf. 1.3.4); it seems that a logarithmic transformation might provide for these difficulties, for if the logarithms are assumed to be normal and homoscedastic the original distribution will be skew with variance proportional to the mean. As to independence, this has also been questioned, notably by Duesenberry (1949), who stresses the interdependence of preferences. No statistical methods for this problem have yet been developed (they would probably amount to a generalization of serial correlation techniques to two or more dimensions), and we therefore prefer to ignore it for the time being.

3.6. In the regression functions income (or total expenditure) will not be the only variable; family size, etc., will also have to be included. This again has some bearing on the shape of the Engel curve; it was found, for instance, that a social class factor cannot easily be combined with a hyperbolic Engel curve.

3.7. The actual choice of the type of function is clearly a complicated matter, which will have to be mainly decided by experiments on the data. My colleague, Mr. S. J. Prais, intends to report on his investigations into this subject separately. The evidence seems to support logarithmic Engel curves, as used in Table 1 below and elsewhere. These have the additional advantage of agreeing with the logarithmic demand functions favoured by demand analysts, e.g., by Stone (1945, 1948, 1951).

3.8. These logarithmic functions,

$$e_i = d_i e^{\beta_i},$$

where e_i is the expenditure on the ith commodity and e total expenditure, do not strictly fulfil the additivity condition $\sum_i e_i = e$. Nevertheless it will be realized that the difference

$$e - \sum_i \alpha_i e\beta_i = e(1 - \sum_i \alpha_i e^{\beta_i - 1})$$

may be close to zero for a considerable range of values of e, since the regression functions are fitted to observations which themselves satisfy the additivity condition.

4. *Qualities*

4.0. The statistical information on average prices per unit for a number of commodities and countries will be surveyed in a forthcoming paper (Houthakker and Prais, 1952). Here we shall only give a brief review of the principal points inasmuch as they affect the British surveys.

4.1. The analysis of qualities on the basis of family budgets starts from the assumption (discussed in 1.2) that all families can buy at the same prices, and that therefore if they do pay different amounts per unit for the same good the qualities bought must be different. "Quality" here includes service in the shop, etc. The problem then arises how qualities, thus defined, vary with income, family size and other determinants of consumption.

4.2. The necessary data on quantities consumed were only available for the working-class budgets, covering about 40 commodities. It was found that in several cases households had not reported quantities, although they had spent something on the item concerned; this made it difficult to analyse quantities by themselves. By excluding such families* it was nevertheless possible to compute average prices for each of the total expenditure-family size groups in which families were classified.† Distinct regularities emerged when average prices were plotted

* Except in one or two commodities they never amounted to more than a few per cent. of the total number of families who reported expenditures.

† Broadly similar calculations were made by Mrs. Ross (1948) for clothing in a small sample of the working-class budgets analysed here. The detailed data she worked with could not be used for the present inquiry.

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against total expenditure, though naturally the correlation varied from commodity to commodity. In general average prices rise with income, but large families spend less per unit than small ones. A clear example of these tendencies in the case of tea is given in Fig. 1 (the symbols do not always represent the same number of families: the weights are usually largest in the 4-person households and tend to decrease from left to right; groups with less than 5 families were omitted).

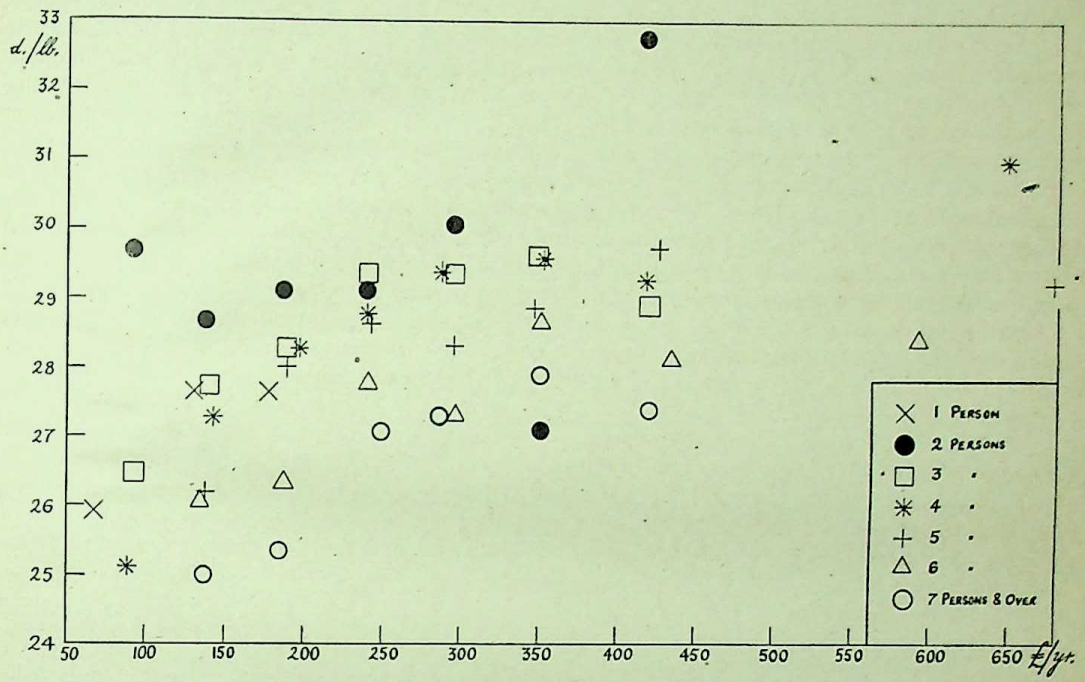

FIG. 1.

4.3. In order to simplify the tendencies evident in Fig. 1 (which is typical of many other commodities) it is necessary first to eliminate family size. The simplest method of doing so is to divide total expenditure by the number of persons; the curvilinearity could be avoided by taking the logarithm of total expenditure per head. The result is shown in Fig. 2 for tea; Fig. 3 is a similar diagram for bacon and ham. It will be seen that apart from the 1-person households, which are a small and special category in any case, the following relation holds fairly closely,

$$v_i = a_i + b_i \log e/n,$$

where v_i = average price per unit of the ith good, e = total expenditure, n = the number of persons and a_i and b_i are constants. The data for different family sizes no longer show any systematic pattern, which proves that family size has been largely eliminated. This observation applies to a considerable number of commodities and will prove to have important consequences (cf. 5.4.3). Some estimates of a_i and b_i are (with standard errors in brackets and correlation coefficients):

	a_i	b_i	r^2
Sugar	2·18	·258 (±·040)	·44
Bacon and ham	7·88	5·36 (±·56)	·64
Beef and veal (home prod.)	3·32	5·95 (±·91)	·45
Pork	6·49	5·54 (±·119)	·31
Tea	20·5	4·42 (±·46)	·65

Prices are in pence per lb. and total expenditure in £ per year.

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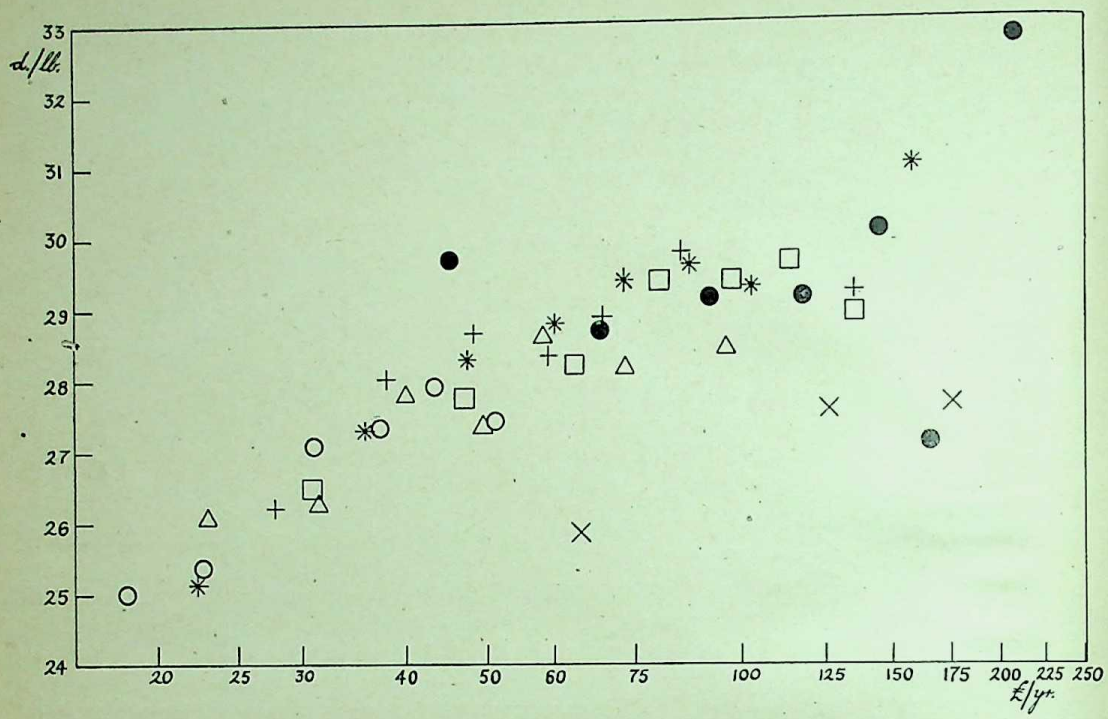

FIG. 2.

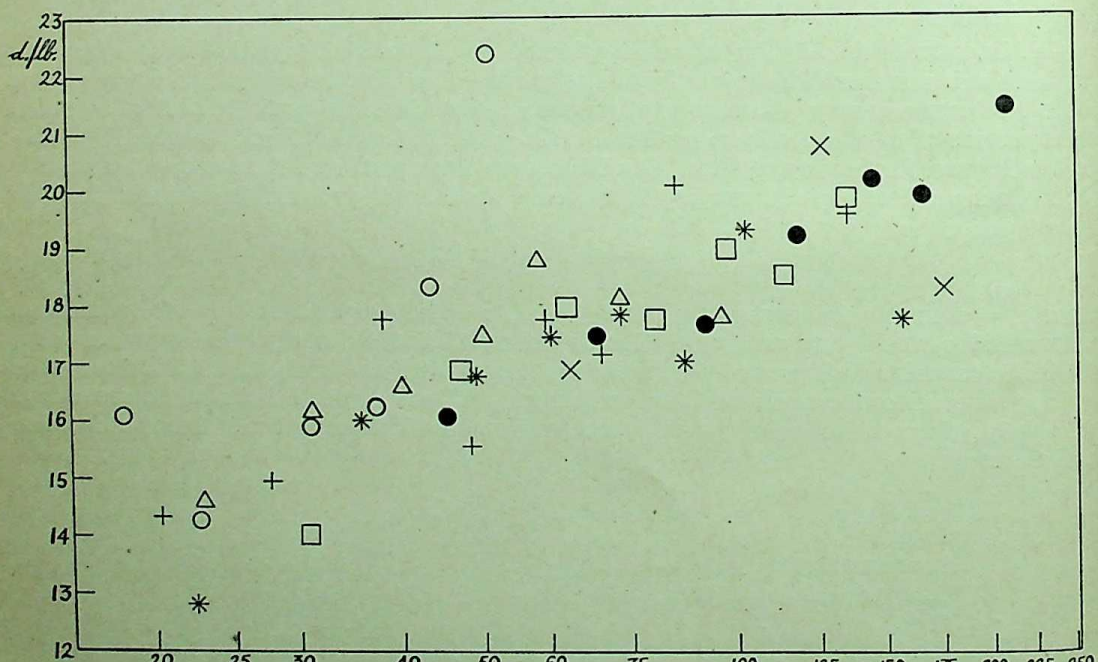

FIG. 3.

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4.4. From formulae of this kind one can deduce "quality elasticities", defined as the proportionate rise in the average price per unit associated with a small proportionate rise in income. In our case this is

$$E_i = \frac{e/n}{p_i} \frac{p_i}{\delta e/n}.$$

For the above equations one finds (at $e/n = 50$, as E_i is not constant) for

Sugar	·043
Bacon and ham	·160
Beef and veal (home prod.)	·192
Pork	·151
Tea	·069

These quality elasticities are the differences between the expenditure elasticities usually provided by family budgets and the quantity elasticities (referring to physical weight or to value at constant prices) needed for demand analysis by time series methods.

5. *Family Composition; Unit Consumer Scales*

5.0. The distinction between specific and income effects of variations in preferences, introduced in 1.3.1 above, is crucial for the problem of the influence of family composition on consumption. Family consumption in quantitative term means a specification of the members of a household by age and sex, and the problem is how to relate the consumption of different items to this specification. It is evident that differences in family composition do not affect all items of expenditure in the same way. Thus the birth of a baby will have no specific effect on the household's demand for men's clothing, but a considerable specific effect on its demand for babies' clothing. This is an extreme example, but more moderate differences in specific effects will be found between nearly all commodities. On the other hand, the income effect is by its nature relevant to all goods, with an intensity dependent on their respective income elasticities.

5.1.0. The usual way of taking family composition into account is by so-called "equivalent adult" or "unit consumer"* scales, which reduce the composition vector to a weighted sum, the number of unit consumers. These scales usually apply to total food consumption, in which case the weights are allegedly based on physiological considerations; sometimes also to clothing or housing. Their economic significance has been questioned, especially by Allen (1942), who in fact interpreted them much more charitably than most constructors of these scales intended. Various points in his discussion call for some comment.

5.1.1. Professor Allen observes that the unit consumer scales will be different according to the item concerned, and that in addition there will be some average scale for reducing total expenditure. We may associate the first type with the specific effects, and the second type with the income effects distinguished above. If the members of a family are divided into m categories and the number of persons in the ith category is denoted by n_i, the number of unit consumers for the jth commodity ($j = 1, \ldots g$) will be $(k_{j1}n_1 + k_{j2}n_2 + \ldots + k_{jm}n_m)$, where the k_{ji} are the weights. Similarly the number of unit consumers on the total expenditure scale may be expressed as $(k_1n_1 + \ldots + k_mn_m)$. In each case the first k is assumed to be unity to avoid proportionality (all other categories of persons are thus given a weight relative to the first category; if this is adult males the name "equivalent adult (male)" is explained).

5.1.2. The Engel curves considered by Allen are straight lines†; the expenditure function becomes

$$\frac{e_j}{\sum_i k_{ji}n_i} = a_j + b_j \frac{e}{\sum_i k_in_i} \qquad (j = 1, \ldots, g) \qquad \ldots \quad (1)$$

* This term was suggested by Mr. M. J. Farrell, and will be used here throughout as it seems preferable both on logical and on linguistic grounds.

† The objections discussed in 3.2 and 3.3 are not relevant if one confines oneself to a section of the income range where the set of goods actually bought remains unchanged.

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in the notation of 3.8; a_j and b are constants and all summations cover the whole range of the suffix concerned. After some multiplication and summing over all goods we get

$$\sum_j e_j = \sum_j \sum_i a_j k_{ji} n_i + \sum_j \sum_i b_j k_{ji} n_i \frac{e}{\sum_i k_i n_i}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Since $\Sigma e_j = e$ this implies the following identities for all e and n_i in the range considered:

$$\sum_i \sum b_j k_{ji} n_i \equiv \sum_i k_i n_i \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

and

$$\sum_j \sum_i a_j k_{ji} n_i \equiv 0. \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

(3) leads to

$$b_1 k_{1i} + b_2 k_{2i} + \ . \ . \ . \ + b_g k_{gi} = k_i \qquad (i = 1, \ . \ . \ . \ . \ , m), \quad . \quad (5)$$

i.e., the total expenditure scale is an average of the specific scales weighted by the income derivatives. If we take $i = 1$, for which all the k's are one, we find $\sum_i b_i = 1$. The other identity (4) defines a system of homogeneous equations

$$a_1 k_{1i} + a_2 k_{2i} + \ . \ . \ . \ + a_g k_{gi} = 0 \qquad (i = 1, \ . \ . \ . \ . \ , m). \quad . \quad . \quad (6)$$

We may assume that there are generally fewer categories of persons than items of expenditure ($m < g$), in which case the conditions (6), regarded as equations in the a's, can normally be fulfilled. If there are more types of persons than goods, however, these scales can only hold if the scales are linearly dependent or if all the a's vanish.

5.1.3. The doubts voiced by Allen (1942) on the validity of these scales are based on an interpretation of the linear Engel curves fitted separately for different family types without actually using such scales. He predicted the behaviour of the slopes and intercepts of these lines for various commodities by *a priori* arguments, and then found some discrepancies between his theory and the estimated slopes and intercepts. Unfortunately no significance tests were made (in any case the estimates were obtained by graphical methods), which is all the more regrettable because the linearity of the functions is not confirmed by an inspection of the data. This makes graphical estimation very unreliable, as is in fact borne out by a least-squares analysis of some of the figures Allen used. Even if the standard errors were as small as 10 per cent. of the regression coefficients to which they belong, most of his conclusions would be well below the usual levels of significance. The interpretation of the estimates thus becomes largely a matter of judgment, and one may well find the agreements between theory and facts, particularly in the case of food, more striking than the disagreements.

5.1.4. One of Allen's objections to equivalence scales was that the effect of an additional child on food expenditure appears to depend on how many children there are already. This difficulty could easily be removed by suitably extending the concept of a "category of persons" (cf. 5.3.1), but a more elegant explanation, based on the distinction between specific and income effects, turns the apparent discrepancy into a confirmation of the theory. Consider equation (2), leaving out the summation over commodities, and differentiate with respect to n_h.

$$\frac{\partial e_j}{\partial n_h} = a_j k_{jh} + b_j e \frac{(\sum_i k_i n_i) k_{jh} - (\sum_i k_{ji} n_i) k_h}{(\sum_i k_i n_i)^2}. \quad . \quad . \quad . \quad . \quad (7)$$

Generally speaking the net effect of an additional child on food consumption will increase with total expenditure, and the numerator of the coefficient of e will therefore be positive if b_j is positive (as is no doubt the case with total food). This numerator does not depend on n_h, since the terms with n_h cancel out. Differentiating again we get

$$\frac{\partial^2 e_j}{\partial n^2_h} = - \ 2 b_j e (k_{jh} \sum_i k_i n_i - k_h \sum_i k_{ji} n_i) \frac{k_h}{(\sum_i k_i n_i)^3}. \quad . \quad . \quad . \quad . \quad (8)$$

and k_h being positive this implies

$$\frac{\partial^2 e_j}{\partial n^2_h} = - \ 2 \frac{\partial^2 e_j}{\partial n_h \partial e} \frac{k_h e}{\sum_i k_i n_i} < 0. \quad . \quad . \quad . \quad . \quad . \quad (9)$$

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Consequently the net effect of an additional child will be smaller the more children there are already, as noted empirically by Allen and by Nicholson (1949, p. 388). It is indeed intuitively obvious that under the above conditions an increase in the number of children, which will reduce total expenditure per unit consumer, must lead to a reduction in the food consumption of the initial members of the family, and the value of this reduction will increase with the size of the family. In other words the income effect will counteract the specific effect to an increasing extent. We should add, however, that the decreasing net effect of children observed in the data may also be due to economies of scale.

5.2.0. The principal attraction of unit consumer scales, when improved by distinguishing specific and income scales, is that they permit all households to be dealt with on the same footing. This is not the case if one divides families into types and analyses these separately, as was done by Allen (1942) and Henderson (1949, 1950), and also by Nicholson (1949) for a selection from the U.K. working-class survey. Nicholson's investigation was an important advance in the study of household consumption, but at the same time clearly illustrates the limitations of this procedure.* In the first place the sample had to be selected very carefully, excluding all families whose composition had changed during the survey (e.g., where a child was born), and where there were persons aged 14 and over other than one man and one woman. This was necessary as families were to be classified by the number of children, but it reduced the number of available budgets from about 2,000 to about 800. In addition London households were kept separate, as their consumption was thought to be too much affected by higher rent and travelling expenses; this further reduced the number of families to 704. Some of the cell-frequencies consequently became quite small, although for regression purposes this does not matter if cell-averages are weighted by the number of observations they represent.

5.2.1. The ages of the children were not taken into account in Mr. Nicholson's calculations, which may introduce a slight bias into the regression coefficients for total expenditure, because the average age of the children within each family type will rise with the age of the father and hence, in many cases, with his earnings. Moreover a family with two small children is put in the same category as one with two children near school-leaving age, although the consumption pattern of the former family may be more like that of a family with only one older child; in a more general form this is of course the principal argument against all family type classifications. The separation of London families is also a questionable point; are they really more different from Midland families than Midland families are from those further North? One wonders if it is wise to go so far in sacrificing coverage and size of sample to an unattainable uniformity of the observations; it may be better to take a greater variety, and rely to some extent on randomization.

5.2.2. It might be objected that in our own analysis we also classify families by size (cf. 2.3.3) so that we are also working with family types, and possibly not even very suitable ones as such. The difference with the authors just mentioned is that our classification is used only to get sufficient variation in the independent variables; in the actual regression analysis all families are dealt with simultaneously. An example of this referring to the Nicholson sample is given in Table 1.

5.3.0. In order to substantiate the favourable view of unit consumer scales here taken it is necessary to extend their scope in various ways. To begin with we must consider them in connection with non-linear Engel curves. Formula (1) in 5.1.2 should then be rewritten as

$$\frac{e_j}{\Sigma k_{ji} n_i} = a_j\left(\frac{e}{\Sigma k_i n_i}\right) + b_j\left(\frac{e}{\Sigma k_i n_i}\right)\frac{e}{\Sigma k_i n_i}, \qquad (10)$$

where a_j and b_j now depend on total expenditure (or income) per unit consumer. This generalization clearly covers all possible Engel curves. The conditions (5) and (6) will then no longer hold identically, except for $i = 1$. More particularly, if the k_{ji}'s are constants the k_i's, as given by (5), will in general vary with total expenditure. Thus if a category of persons has a high relative weight in the specific scales for items with a low income elasticity, and conversely, then its relative weight in the income scale will decrease as income rises. Concerning the conditions (6), one

* No criticism is intended or implied, since for an analysis with limited resources and with special emphasis on children the family type method may well be appropriate, especially if one regards Allen's criticism of equivalence scales as decisive.

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may perhaps rely on the statistical fitting procedure, as explained in 3.8. The proof of (9) requires some additional assumptions which are not difficult to work out.

5.3.1. The method of dividing the members of a family into categories provides a further means of improving the applicability of unit consumer scales. The simplest idea is to work with the number of persons in each age-sex group irrespective of the numbers in other groups. If one wants to allow for non-linearities of the kind mentioned in 5.1.4 (which, as we have seen, may not be necessary from a theoretical point of view), it is perfectly possible to introduce "children beyond the second" or "children in families with two or more women" as separate categories (an example is given by Quenouille (1950), p. 29). In this way most interactions and higher-order effects can be taken into account, without abandoning the formally linear unit consumer scales. Similarly one may introduce a constant into the scales by putting one of the n_i equal to unity; this trick, which amounts to interpreting one of the categories of persons as "the household independent of its composition", is necessary for those rare commodities which experience no specific family size effects at all.

5.4.0. Having attempted to restore unit consumer scales to the favour of consumption analysis we must now discuss the actual estimation of the weights. The Engel curves we have in mind can be described by

$$\frac{e_j}{\sum_i k_{ji} n_i} = f_j\left(\frac{e}{\sum_i k_i n_i}\right), \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

where the k_{ji} are still constant but the k_i are not necessarily so (cf. 5.3.0). It would be convenient if we could proceed with the estimation in two stages, one being aimed at the specific scales and the other at the income scale. Such a procedure would be possible if there were variables for which the specific scale was known from external evidence, for then the left-hand side of (11) would be known and the parameters on the right-hand side could be estimated by maximum likelihood methods once the mathematical form of f_i is specified. The resulting income scale could then be regarded as known for the estimation of the specific scales. The alternative procedure of first estimating all the specific scales and then calculating the income scale by means of formula (5) evidently offers formidable difficulties.

5.4.1. Computationally the possible variability of the income scale is of course a source of great complications in an already very complicated problem. Fortunately one can find reasons for expecting that this variability will not be very important in practice. The principal characteristic of unit consumer scales is the weight of school-children in relation to adults. Now the specific effect of children is mainly felt in food, clothing and education. Of these three it is nearly always found that food is income-inelastic, clothing has an elasticity of about unity and education has a high elasticity. As a first approach one may therefore suppose that in the income scale these three specific effects will balance to a considerable extent, and that one is provisionally justified in working with constant income weights.

5.4.2. Next one has to find items for which the specific scale can be predicted with some confidence. Foodstuffs are clearly unsuitable, since they are normally consumed collectively; we have to look for more personal items, of which clothing is the most promising example (cf., however, 5.4.3). Men's, women's and children's clothing are stated separately in the two surveys under consideration, and for the first two categories the specific scales are quite simple.* For the income scale one may as an approximation take equal weights for all members of a household, merely in order to get a first impression. The original figures for women's clothing, plotted against total expenditure, are depicted in Fig. 4, while Fig. 5 gives expenditure on women's clothing per woman in relation to total expenditure per head. It can be seen that this transformation of the variables largely eliminates differences between families of different size, though the households with 6 and more persons still seem to be somewhat distinct. This is no doubt due to the crudity of the method; if the weights had been determined by regression analysis a closer fit would have been obtained.

5.4.3. This preliminary result may help to show the reality of the relationship expressed in (11). Nevertheless it would be desirable if the income scale could be estimated from a wider

* The only problem is how to weight persons of 14–17 as compared to persons of 18 and over, no further information on ages being available. In Fig. 5 these two categories have equal weights, but this could no doubt be improved on.

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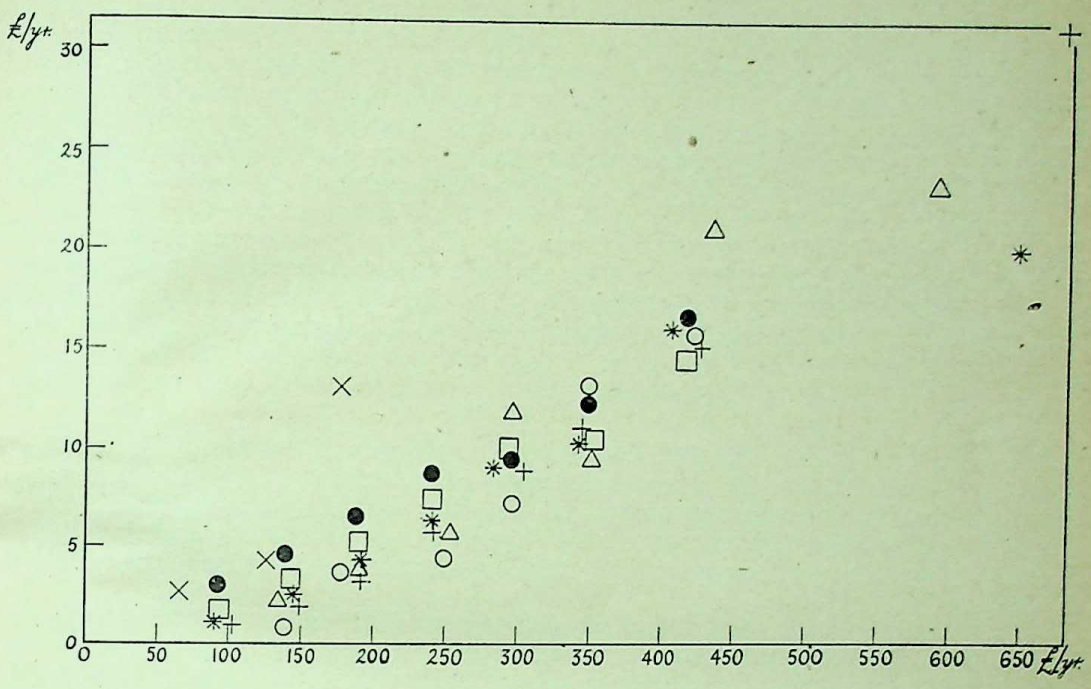

FIG. 4.

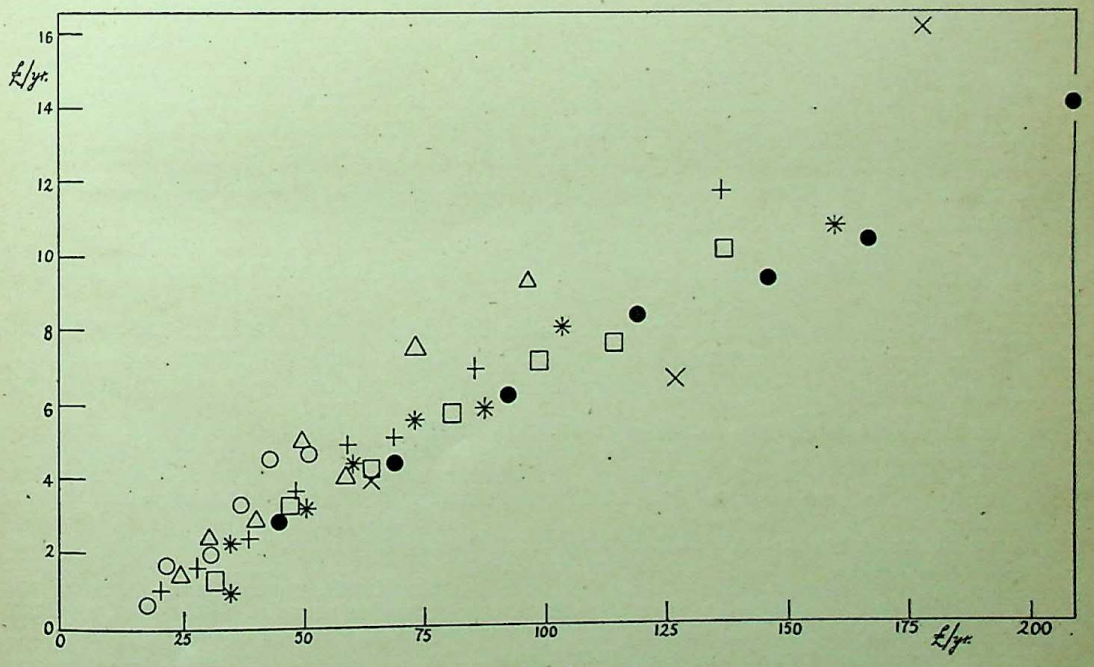

FIG. 5.

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range of data. Here the material on average prices paid discussed in Section 4 provides a solution. The quantity of a good consumed will nearly always depend specifically on family size, but in many cases the quality will only be related to this factor through income effects. This will not always be true, not only for the reasons mentioned in 2.1.0 and 2.1.1, but also because a household may buy different kinds of, for instance, fish or vegetables if there are children. Nevertheless for commodities such as tea, meat, flour, etc., the specific effect of family size should be negligible. Figs. 2 and 3 have already shown that even a simple income scale is remarkably successful in eliminating income effects on qualities, so that this type of analysis seems to open great possibilities.

5.4.4. In applying this approach it is of great importance to choose an appropriate type of function, for experience shows that in multiple regression analysis a wrong choice of regression curve may lead to serious biases in the estimates.* In the case of qualities there was considerable evidence for a semi-logarithmic function, which combined with (11) leads to the equation

$$p_j = a_j + b_j \log \frac{e}{\Sigma k_i n_i} + \varepsilon. \quad . \quad . \quad . \quad . \quad . \quad (12)$$

In this case the error term ε might well be assumed to be normally and independently distributed (cf. 3.5), but the estimation of the parameters is greatly complicated by non-linearity. Customary computation techniques are powerless here, and the only possibility seems to be an iterative solution using electronic equipment. At the time of writing no results thus obtained are available yet, but it is hoped to give them in the Monograph together with a discussion of the technique of calculation.

5.5.0. The last problem concerning family composition which we have to discuss is the so-called "cost of children". This has recently attracted some attention because of the interest of the Royal Commission on Population in children's allowances and their possible effect on differential fertility. We do not propose to go into the social or ethical aspects of this question, but will only try to indicate briefly the relevance of family budgets to its analysis in numerical terms; some conceptual discussion cannot be avoided, however.

5.5.1. In one of the papers presented to the Royal Commission on Population Hajnal and Henderson (1950) put the question as follows: "How great an addition in income is needed to make parents as well off as a childless couple?" This question, if meaningful at all, is not one on which expenditure data have anything to contribute, since they tell us nothing of the pleasure or displeasure which the presence or absence of children, quite apart from their effect on consumption, will cause to their parents or potential parents. The authors in fact mean something more restricted, viz., "that increase of income which enables the parents to pay any additional expenditure occasioned by a child and then to have the same income left over for their own use". In another paper Henderson (1949–50) has described this as a compensating variation, in analogy with a synonymous concept in the theory of consumer's surplus. It might be added that the latter concept is defined for given and fixed preferences, a condition which is not fulfilled in the present case.† Henderson's approach is based on two assumptions, viz., that expenditure can be allocated between parents and children, and that parents' satisfaction depends only on their personal consumption, if it can be calculated.

5.5.2. The first assumption leads us back to the discussion of unit consumer scales, but this technique is not used by Henderson or by Nicholson (1949), who made similar calculations. They rely instead on the analysis of "standard commodities", introduced by Rothbart (cf. Madge,

* For this reason it is also important to classify the observations in an efficient manner if their number is too large for ungrouped computation (cf. also Nicholson (1949), p. 363). How an optimal classification (which would minimize the covariance matrix of the estimates subject to, for instance, a constraint on the number of groups) can be obtained is incidentally a difficult problem which might repay the attention of statisticians.

† A similar remark applies to the analogy between the two effects of variations in preferences and the Slutsky-Hicks equation (cf. 1.3.1). In our case the analogy seems more legitimate than in Professor Henderson's case: the income effect of taste variations is interpreted in a purely nominal sense, not necessarily related to any change in utility; the extended compensating variation on the contrary seems to have utility implications as well. We should like to stress that without additional assumptions data on observed consumption provide no information whatever about the effect of variations in preferences on the level of utility.

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1943), which consists in comparing families with different numbers of children by their expenditure on items solely consumed by the parents, such as drink, tobacco and adult's clothing. For instance, if a family with two adults and no children spends £50 per year on adult clothing out of a total expenditure of £400 per year, and a similar family with one child spends the same on adult clothing out of £500 per year, then the expenditure attributed to the child is £100 per year. This method consists, in our terminology, in finding the income scale for variations in family size from expenditures for which the specific scale is known. We have already seen that quality data may be more effective for this purpose (cf. 5.4.3), but these were not available to Henderson and Nicholson. In any case the usefulness of household budgets for this purely descriptive purpose is incontestable.

5.5.3. By interpreting the figure thus found as the "cost" of a child Henderson gets on more dangerous ground, however. This somewhat commercial term suggests, in accordance with his second (implicit) assumption, that the consumptions of parents and children are independent in the sense that children's consumption is a prior charge determined by their "needs". This assumption would hold if the expenditure function could be expressed as

$$e_j = f_j(e) + g_j(n_c), \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

where n_c is the number of children. Such a function was used by Allen and Bowley (1935, p. 18), but it has since been found to be misleading, particularly by Allen (1942), who proved that the first right-hand term in (13) will depend on n_c as well. Henderson's and Nicholson's calculations provide further confirmations of this phenomenon. The practical meaning of this is that if family income rises, part of the increase will be spent on children's consumption, although it is difficult to see in what way the "cost" of a child has risen. Consequently if parents were subsidized to the extent that they bought as much adult's clothing as childless couples, the former category would in fact be overcompensated because they also derive satisfaction from the larger expenditure on children which the subsidy makes possible. The "cost" interpretation appears to be more appropriate to professional foster-parents than to the people whose birth-rate the Royal Commission on Population wanted to influence.

6. *Regional Variations*

6.0. No extensive investigation of regional differences in consumption was contemplated for the present analysis, although for the working-class budgets the possibility of such an investigation at a later date has been kept in mind during the planning of the punched card work.* Some calculations on this subject have been made for the sample studied by Nicholson (1949), where London families were separated from those in the remainder of Great Britain. (Our own sample also covered Northern Ireland.)

6.1. All households in Nicholson's sample contained one man, one woman and 0, 1, 2 or 3 children under 14 years. In order to deal with all of them uniformly an expenditure function had to be used in which the number of children was the only family size index, as their ages were unknown and no adult/children weighting could be used. The expenditure of London families was assumed to differ by a constant percentage from the expenditure of similar families elsewhere. The regression formula used was

$$\log e_j = a_j + b_{1j} \log e + b_{2j} n_c + b_{3j} l, \quad . \quad . \quad . \quad . \quad (14)$$

where b_{1j} is the elasticity of the jth item of expenditure with respect to total expenditure, b_{2j} is the children coefficient, n_c is the number of children, b_{3j} is the London coefficient, and l is a dummy variable equalling 1 if the family lives in London and 0 otherwise. The meaning of b_{2j} and b_{1j} can be seen more clearly if we consider the effect of a change of one unit in n_c or l on e_j; this works out at 100 $(10^{b_{ij}} - 1)$ per cent. of e_j (i = 2, 3). The percentage differences thus obtained are also given in Table 1; we see, e.g., that an additional child increases expenditure on butter by 6·1 per cent. on the average, but that the mean expenditure on butter of families in London is 31·2 per cent. below that of comparable families elsewhere.

* In general the cards are intended to be suitable for almost all conceivable analyses of the data without further reference to the original documents.

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6.2. Inspection of Table 1 shows that the standard errors of the total expenditure elasticities are on the whole fairly small. Only one commodity is found to be significantly inferior, viz., condensed milk; the negative elasticities of three other goods have large standard errors. The effect of children is significantly positive for most food items and for clothing and education, but most other commodities experience only income effects so that the children coefficient is negative. It can even be seen that the children coefficient tends to be largest in absolute value for highly income-elastic commodities such as theatres, holidays and food for animals (although this might also indicate a negative specific effect of children). The very large percentage difference attributed to a child in children's clothing reflects the fact that childless households spent very little on this item (what they did buy was presumably intended for children born after the survey). The London difference is clearly dominated by the specific effects on rent and travelling expenses (cf. 1.2.0), which have corresponding negative income effects on most other commodities. Unfortunately there was an imperfection in the data which has tended to exaggerate the London difference in the case of highly income-elastic commodities, e.g., furniture, carpets and education. If the number of families in a group was small no averages were given; this happened to some London families with large total expenditures so that the average for London was lower than it should have been.

6.3. The results in Table 1, which are satisfactory on the whole, do not belong to our main analysis and were mainly intended as a preliminary experiment. The use of logarithmic Engel curves and of a multiplicative London effect appears to be successful, but the treatment of children (or rather family composition in general) could be improved. The proportional effect of the addition of a child, as given by (14), is constant, so that the absolute effect will increase with family size. This is not in accordance with the argument in 5.1.4. In the calculations of the Monograph a formula with a unit consumer scale will be used, viz.

$$\log \frac{e_j}{\sum_i k_{ji} n_i} = a_j + b_j \log \frac{e}{\sum_i k_i n_i}, \qquad (15)$$

where the weights of the income scale will be determined by the method of 5.4.4. Some first examples are given in Section 7.

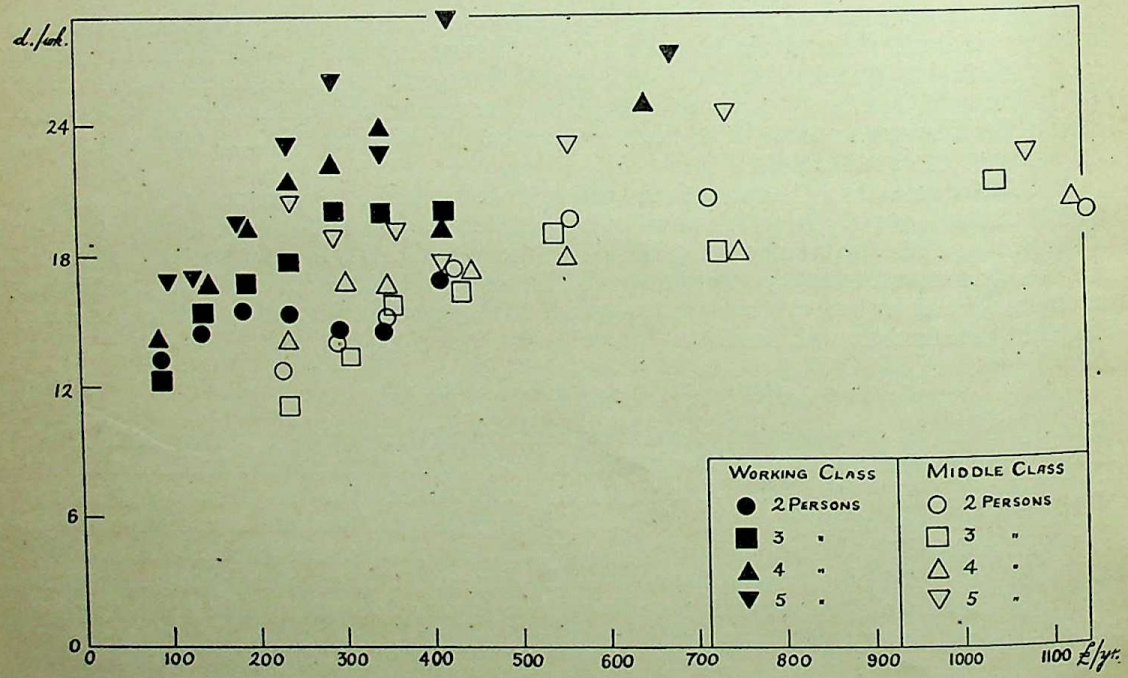

FIG. 6.

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7. *Social Class Differences*

7.0. The uniform treatment of middle-class and working-class families in the present analysis makes it possible to detect differences in consumption between these two social classes which cannot be ascribed to total expenditure or family size. The existence of differences of this kind can be established in several cases; Fig. 6 provides a striking example: expenditure on tea is much less in middle-class families than in working-class families of the same total expenditure and number of heads, except perhaps in two-person families. This is probably connected with a higher coffee consumption in middle-class households. As tea and coffee have no nutritional value this difference could hardly be explained by the nature of the work performed (cf. 1.3.3).

7.1. It was consequently necessary to introduce a dummy variable, analogous to the London factor of 6.1, to enable working and middle-class observations to be used in the same regression analysis.* The equation used so far is

$$\log \frac{e_j}{n} = a_j + b_{1j} \log \frac{e}{n} + b_{1j}s, \quad . \quad . \quad . \quad . \quad . \quad (16)$$

with a social class factor s which is 1 for a middle-class household and 0 for a working-class household; this factor is again multiplicative with respect to e_j. The number of heads is used as a family size index. Some estimates are

	b_{1j}	b_{1j}	R^2	*Middle Class per cent Difference.*
Sugar	·33 (±·02)	−·22 (±·03)	·68	−37
Bacon and ham	·64 (±·04)	−·44 (±·05)	·76	−64
Beef and veal (home prod.)	·70 (±·09)	−·08 (±·06)	·65	−17
Pork	·54 (±·05)	−·59 (±·11)	·41	−74
Coffee	1·28 (±·12)	+·85 (±·15)	·82	+610
Cocoa	·25 (±·07)	−·17 (±·09)	·12	−32
Tea	·49 (±·03)	−·40 (±·04)	·70	−60

The social class coefficients are seen to be quite considerable and significant in most cases. In comparing the total expenditure elasticities with those of Table 1 it should be remembered that the Nicholson data cover only a selected sample of 791 working-class households, whereas the above figures also refer to an additional 1,428 working-class and 1,361 middle-class families. The different ways of introducing family size may have affected the total expenditure elasticities, but of the whole the two sets of estimates agree fairly well where they can be compared. When using these elasticities the remark at the end of 4.4 should be borne in mind.

8. *Income and Total Expenditure*

8.0. In 2.2 we have explained the choice of total expenditure as the main explanatory variable, the decisive reason being the absence of income figures in the working-class budgets. For the middle-class families the income of the head was one of the items on the questionnaire. It is not clear how exactly this income was defined, particularly if it included property income, but in view of the paucity of information on the income-consumption relation in Great Britain before the war an attempt to utilize these data has nevertheless been undertaken. While the results cannot be said to be very illuminating for this purpose, they do give rise to some remarks on the design of budget surveys.

8.1. In this calculation only middle-class families with one earner (presumably the head) were considered; they were classified by the income of the head and by the number of persons. The number of observations was 1,095, or about 80 per cent. of the total number of middle-class households in the sample. As a first approach a linear regression was calculated, viz.,

$$e = ·947\ (\pm ·024)M + 10·9\ (\pm 2·5)n + 42·6 \qquad R^2 = ·951. \quad . \quad . \quad (17)$$

* Stuvel and James (1950) think it preferable to analyse the two classes separately, but our results suggest that the social class factor will make this unnecessary and that a uniform income elasticity does not distort the facts unduly.

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TABLE 1

No.	Group (abbreviated)	a	Total Expenditure Elasticity	Children Coefficient	London Coefficient	R^2	Children % Difference	London % Difference
A1.	Bread	1·34	−0·01±0·06	0·074±0·009	−0·022±0·026	0·69	18·6	−5·0
A2.	Flour	0·50	0·10±0·14	0·074±0·019	−0·191±0·058	0·46	18·6	−35·6
A3.	Cakes, etc.	−1·50	0·92±0·12	0·003±0·017	−0·207±0·051	0·64	·7	−37·9
A4.	Oatmeal, etc.	−2·32	0·92±0·11	0·112±0·015	−0·117±0·046	0·79	29·3	−23·6
A5.	Butcher's meat	0·30	0·46±0·06	−0·011±0·008	0·015±0·025	0·64	−2·6	3·5
A6.	Sausages, etc.	−0·15	0·40±0·08	0·037±0·010	−0·036±0·031	0·54	8·8	−8·0
A7.	Rabbits, etc.	−3·54	1·34±0·35	−0·122±0·048	−0·338±0·144	0·39	−24·5	−54·1
A8.	Bacon, etc.	−0·78	0·70±0·09	0·001±0·013	−0·138±0·038	0·64	·1	−27·3
A9.	Fish	−2·17	1·04±0·02	−0·039±0·017	0·048±0·050	0·70	−8·7	11·6
A10.	Fresh milk, etc.	−0·47	0·66±0·07	0·061±0·009	0·055±0·028	0·80	15·1	13·6
A11.	Condensed milk	2·29	−0·74±0·27	0·142±0·037	0·205±0·113	0·38	38·8	60·4
A12.	Cream	−5·81	1·97±0·24	−0·145±0·033	0·068±0·101	0·72	−28·4	16·9
A13.	Butter	−0·23	0·54±0·08	0·026±0·011	−0·162±0·034	0·65	6·1	−31·2
A14.	Margarine	1·01	−0·23±0·14	0·149±0·019	0·038±0·059	0·63	40·9	9·0
A15.	Lard	−0·39	0·31±0·14	−0·011±0·020	−0·399±0·060	0·56	−2·6	−60·1
A16.	Cheese	−0·44	0·41±0·09	0·031±0·013	0·016±0·039	0·42	7·3	3·7
A17.	Eggs	−0·60	0·63±0·07	0·027±0·010	−0·043±0·030	0·70	6·4	−9·3
A18.	Tea	0·36	0·27±0·05	0·028±0·007	−0·026±0·022	0·54	6·6	−5·8
A19.	Cocoa	−0·86	0·27±0·21	0·142±0·028	−0·126±0·086	0·47	38·7	−25·2
A20.	Coffee	−3·48	1·17±0·31	−0·072±0·043	−0·131±0·131	0·31	−15·2	−26·1
A21.	Sugar	0·36	0·20±0·05	0·058±0·007	−0·098±0·020	0·77	14·3	−20·2
A22.	Jam, etc.	−1·09	0·61±0·12	0·061±0·017	−0·034±0·051	0·52	15·1	−7·6
A23.	Potatoes	0·04	0·29±0·07	0·086±0·009	0·070±0·029	0·74	22·0	17·6
A24.	Vegetables, etc.	−2·11	1·10±0·06	−0·014±0·008	0·055±0·025	0·91	−3·1	13·6
A25.	Fruit	−3·43	1·53±0·11	−0·008±0·015	0·020±0 045	0·85	−1·9	4·7
A26.	(Sweets)	—	—	—	—	—	—	—
A27.	Other foods	−1·80	1·09±0·08	0·011±0·011	−0·078±0·034	0·83	2·7	−16·4
A28.	Meals away from home	−6·05	2·36±0·35	−0·180±0·048	0·388±0·146	0·68	−33·9	144·5
AT.	Total food	0·72	0·60±0·03	0·026±0·005	−0·014±0·014	0·91	6·3	−3·1
BT.	Rent or purchase of dwelling, rates, etc.	0·28	0·62±0·06	−0·019±0·008	0·145±0·024	0·83	−4·3	+39·7
C1.	Clothing, men's	−2·05	1·17±0·10	−0·079±0·014	−0·121±0·043	0·81	−16·6	−24·4
C2.	Clothing, women's	−2·90	1·47±0·10	−0·109±0·014	−0·068±0·042	0·88	−22·3	−14·6
C3.	Clothing, children's	−3·70	1·32±0·47	0·586±0·064	−0·184±0·194	0·73	+285·0	−34·6
C4.	Repairs (clothing)	−4·53	1·58±0·18	−0·082±0·025	0·046±0·075	0·72	−17·3	+11·2
C5.	Boots and shoes	−1·12	0·74±0·06	0·090±0·008	−0·050±0·024	0·90	+22·9	−10·9
C6.	Repairs (boots and shoes)	−1·66	0·82±0·08	0·009±0·011	−0·071±0·033	0·75	+2·0	−15·0
D2.	Coal	−1·28	0·36±0·58	−0·150±0·079	−0·161±0·239	0·10	−29·3	−31·0
D3.	Gas	−0·04	0·41±0·07	0·001±0·010	0·232±0·030	0·75	+·2	+71·1
D4.	Electricity	−2·83	1·31±0·21	−0·033±0·028	0·043±0·086	0·55	−7·2	+10·5
D5.	Oil	0·52	−0·18±0·47	−0·010±0·065	−0·310±0·197	0·07	−2·4	−51·8

C3.	Clothing, children's	−4·53	1·58±0·18	−0·082±0·025	0·046±0·075	0·72	−17·3	+11·2
C4.	Repairs (clothing)	−1·12	0·74±0·06	0·090±0·008	−0·050±0·024	0·90	+22·9	−10·9
C5.	Boots and shoes	−1·66	0·82±0·08	0·009±0·011	−0·071±0·033	0·75	+2·0	−15·0
C6.	Repairs (boots and shoes)							
C7.	Cut	−1·28	0·36±0·58	−0·150±0·079	−0·161±0·239	0·61	−2·8	−27·2
D3.	Gas	−0·04	0·41±0·07	0·001±0·010	0·232±0·030	0·10	−29·3	−31·0
D4.	Electricity	−2·83	1·31±0·21	−0·033±0·028	0·043±0·086	0·75	+·2	+71·1
D5.	Oil	0·52	−0·18±0·47	−0·010±0·065	−0·310±0·197	0·55	−7·2	+10·5
D6.	Firewood, matches, candles	−0·62	0·49±0·10	−0·005±0·014	−0·133±0·042	0·07	−2·4	−51·0
DT.	Total fuel and light	0·13	0·58±0·04	−0·010±0·006	0·008±0·018	0·45	−1·1	−26·5
						0·84	−2·3	+1·8
E1.	Soap	−0·91	0·62±0·05	0·023±0·007	−0·055±0·020	0·83	+5·5	−12·0
E2.	Soda	−2·09	0·91±0·08	−0·009±0·010	−0·024±0·031	0·80	−2·0	−5·4
E3.	Ironmongery, tools, etc.	−6·33	2·32±0·41	−0·147±0·056	−0·247±0·169	0·52	−28·8	−43·3
E4.	Household brushes, brooms, etc.	−5·60	1·85±0·33	0·034±0·045	−0·403±0·138	0·51	+8·1	−60·4
E5.	Pottery and glassware	−5·02	1·71±0·45	−0·001±0·061	−0·240±0·185	0·30	−·3	−42·5
E6.	Drapery and haberdashery	−5·82	2·22±0·42	−0·077±0·058	−0·222±0·176	0·45	−16·2	−40·0
E7.	Furniture	−6·20	2·42±0·64	0·058±0·088	−0·755±0·266	0·37	+14·2	−82·4
E8.	Carpets	−9·00	3·33±0·54	−0·169±0·074	−0·813±0·223	0·58	−32·3	−84·6
E9.	Other household utensils	−9·55	3·41±0·41	−0·182±0·056	−0·236±0·170	0·69	−34·2	−41·9
E10.	Tobacco and cigarettes	−1·03	0·85±0·07	−0·009±0·010	0·071±0·030	0·81	−2·1	+17·7
E11.	Rail travelling to and from work	−4·93	1·84±0·53	−0·186±0·073	0·491±0·221	0·44	−34·8	+210·0
E12.	Bus travelling to and from work	−4·05	1·68±0·26	−0·047±0·035	0·072±0·106	0·57	−10·3	+18·1
E13.	Other travelling	−5·69	2·24±0·27	−0·087±0·036	−0·014±0·110	0·69	−18·2	−3·2
E14.	Newspapers and periodicals	−0·98	0·70±0·07	−0·030±0·010	−0·032±0·031	0·73	−6·8	−7·1
E15.	Books, stationery, etc.	−4·34	1·59±0·21	−0·067±0·029	0·044±0·087	0·65	−14·3	+10·5
E16.	Postage, telephone, etc.	−3·55	1·46±0·11	−0·100±0·016	−0·045±0·047	0·85	−20·5	−9·8
E17.	Cinemas	−2·95	1·31±0·20	−0·036±0·028	−0·057±0·085	0·55	−7·9	−12·4
E18.	Theatres, dances, etc.	−7·20	2·61±0·30	−0·134±0·041	−0·374±0·125	0·70	−26·5	−57·8
E19.	Sports, etc., admission	−4·38	1·62±0·31	−0·014±0·043	−0·309±0·130	0·45	−3·1	−50·9
E20.	Education, etc.	−8·87	3·01±0·77	0·177±0·106	−0·481±0·321	0·35	+50·2	−66·9
E21.	Hairdressing	−4·34	1·73±0·15	−0·045±0·020	0·059±0·061	0·81	−9·8	+14·6
E22.	Laundry charges	−4·54	1·80±0·22	−0·161±0·031	0·148±0·093	0·74	−30·9	+40·7
E23.	Doctor, dentist, etc.	−7·82	2·95±0·42	0·021±0·058	−0·593±0·174	0·61	+5·0	−75·0
E24.	Medicine, etc.	−3·06	1·29±0·19	−0·018±0·026	−0·140±0·079	0·57	−4·0	−27·6
E25.	Hospital funds	−2·55	1·01±0·23	−0·017±0·031	−0·015±0·094	0·36	−3·8	−3·5
E26.	Unemployment, National Health and Pensions Insurance	0·57	0·23±0·08	−0·002±0·011	0·002±0·034	0·19	−·6	+·5
E27.	Insurance, pension funds, etc.	−3·53	1·69±0·15	−0·019±0·020	−0·092±0·061	0·79	−4·3	−19·2
E28.	Trade Unions, Friendly Societies, etc.	−1·32	0·84±0·24	−0·008±0·032	−0·207±0·098	0·30	−1·8	−38·0
E29.	Licences	−6·92	2·61±0·54	−0·159±0·074	−0·713±0·223	0·48	−30·6	−80·6
E30.	Domestic help	−9·72	3·36±0·65	−0·210±0·089	−0·379±0·269	0·47	−38·4	−58·2
E31.	Holiday expenditure	−9·60	3·52±0·53	−0·256±0·072	−0·610±0·219	0·62	−44·6	−75·4
E32.	Food for animals	−6·04	2·16±0·41	−0·162±0·056	−0·117±0·169	0·50	−31·2	−23·6
E33.	Drink	−6·47	2·52±0·38	−0·102±0·052	−0·213±0·159	0·55	−20·9	−38·8
E34.	Other expenditure	−6·78	2·77±0·15	−0·055±0·020	−0·037±0·061	0·91	−12·0	−8·1
ET.	Total other items	−2·53	1·69±0·03	−0·029±0·004	−0·034±0·012	0·99	−6·5	−7·6

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Here M means money income net of income tax and n the number of persons. A logarithmic formula yielded

$$\log e = \cdot 890\ (\pm \cdot 038) \log M + \cdot 345 \qquad R^2 = \cdot 939; \quad . \quad . \quad . \quad (18)$$

the coefficient of the number of persons was not significant. Though satisfactory from the statistical point of view these estimates are rather disturbing because of the low savings figures which they imply ("savings" include insurance premiums in this context, as the latter could not be eliminated). Even comparatively high income families are found to be spending more than they earn. This had in fact already been noticed by Massey (1942, p. 179), who ascribed it to incomes of supplementary earners being left out. In our case this explanation cannot hold, or rather it can hold only for property incomes that were not stated. In principle it would be possible to check on stated incomes by the income-tax payments recorded by the families, but in practice this does not work out very well. However, these tax figures do not suggest that the incomes quoted in the documents were understated.

8.2. It is nevertheless hardly believable that nearly all these families in stable economic situations were dissaving, so that one cannot help doubting the expenditure figures. The main inquiry was held during four weeks spread out over the year, but some families supplied clothing information for the whole year continuously. Mr. Massey (1942, pp. 174–5) discusses the remarkable discrepancy between the 4-weekly and the yearly averages for clothing thus obtained, plausibly explaining it by a tendency to include in the 4-weekly figures some expenditures incurred in other periods. This may well have applied to other items than clothing as well, particularly to those bought infrequently; it does not necessarily bias the elasticity estimates, because the tendency to overestimate clothing estimates was apparently not correlated with income. It might be serious if one tried to estimate national expenditure from budget data, but this is a hazardous procedure in any case. The only way to prevent these discrepancies is to have a continuous inquiry over a longer period, perhaps only for the items where they are most likely to occur.

Acknowledgments

The investigations referred to in this paper could not have been undertaken without the generous co-operation of a considerable number of persons and institutions. This was especially true of the Hollerith work, which involved the punching and subsequent manipulation of well over 100,000 cards. The analysis was started as part of an inquiry into the current demand for foodstuffs of which Dr. James Tobin was then in charge; most of the planning was done jointly with him. The Director of the Department of Applied Economics, Mr. J. R. N. Stone, has taken an active interest in all phases of the work. Mr. S. J. Prais has been working on this project from October, 1950, onwards and has made many useful suggestions. The author accepts full responsibility for any remaining defects. The Ministry of Labour and National Service gave access to the transcripts of the returns for the two budget inquiries, and was always ready to help with additional explanations. The Ministries of Food and of Agriculture and Fisheries, the Royal Aircraft Establishment in Farnborough and the College of Aeronautics in Cranfield kindly undertook extensive parts of the Hollerith work and carried them out in the most helpful spirit, despite the many difficulties of this frequently unusual work. The help of the National Physical Laboratory in Teddington and the University Mathematical Laboratory in Cambridge in allowing the use of their Hollerith equipment was also highly valuable; there Mrs. A. E. Gill and Mrs. M. V. Allnutt did an important share of the punched-card work. The large volume of other computing work was carried out by the Department's computing section and at the National Institute of Economic and Social Research. To all who took part the author expresses his sincere gratitude.

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DISCUSSION ON MR. HOUTHAKKER'S PAPER.

Mr. J. L. NICHOLSON: A little while ago we had an admirable paper from Dr. Tobin, who was then also working at Cambridge, on "A Statistical Demand Function for Food in the United States". Mr. Houthakker has now given us a most interesting and illuminating paper which ranges, swiftly but deftly, over a large number of the theoretical problems connected with the analysis of family budgets. The author deserves to be congratulated, not only for the undoubted excellence of his paper, but also for his energy and enterprise in undertaking this work, which must have involved an enormous amount of tabulation and computation alone. We should also, I think, be grateful to Mr. Stone for his patronage of this large-scale undertaking, as well as to the Ministry of Labour for supplying the detailed information and to other Departments for their assistance.

Perhaps I might say a word, first, about the kind of function which is chosen to represent the relationship between income (or in this case total expenditure) and expenditure on particular items. There are some advantages and some disadvantages in using an ordinary polynomial, and the same must be said of logarithmic functions. The additive property of the former is sometimes a very useful safeguard; for instance if one is making a prediction from one level of income to another and the calculation is required in a hurry. A logarithmic function on the other hand may, as Mr. Houthakker suggests, give a better fit at very low incomes, because it takes account automatically of the fact that consumption cannot be negative; and it clearly involves more realistic assumptions about homoscedasticity. I accept the point that although logarithmic functions do not satisfy the additivity condition, the discrepancy in practice is likely to be very small, since the data to which the functions are fitted do of course satisfy this condition. But the same argument applies surely to functions of the ordinary values fitted to data which cannot show negative consumption. However, we cannot really decide which is the best type of function to use on this kind of data until we have had a good deal more experience.

Mr. Houthakker questions whether the average expenditure on clothing, shown in the four weeks of the Ministry of Labour's inquiry, should be adjusted and brought into line with the annual data on clothing for the same households. Expenditure on certain items, such as clothing, sometimes has a habit of being recorded if it occurs just before or just after the week of the inquiry. This would tend to raise the figures of total expenditure, but not perhaps by as much as the expenditure on clothing (and similar items) is raised, because of the tendency for errors to compensate. Whether one is likely to get nearer the truth by adjusting the figures shown in the main part of the inquiry or by leaving them unaltered is a very nice point.

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Undoubtedly the most interesting parts of Mr. Houthakker's paper, and the parts which may be found most fruitful in subsequent work, are his contribution on unit consumer scales and—particularly in its relation to this—his analysis of qualities (or average prices). For a great many problems some kind of unit consumer scale is obviously useful, and I should not be surprised if such scales were rehabilitated by Mr. Houthakker's analysis. The determination of the income part of the unit consumer scale, by means of the information on qualities, leads to some very interesting possibilities. I hope that the monograph which is promised will contain a fuller discussion of these problems. Mr. Houthakker suggests, for instance, the use of the data on qualities to estimate expenditure on children, which is what I was attempting to do, by a rather cumbersome method, in the paper to which he refers. But he has not made any estimates himself. Just to get some idea of the order of magnitude, I have made a very rough calculation, fitting a curve by eye to the points shown in his diagram relating to tea. It appears from this crude calculation that, when families with 4 persons are compared with families with 2 persons, the difference between total expenditure at the average standard of living is just under 30*s*. per week. My estimate of the expenditure on two children was 26*s*.

Remembering that some of the 4-person families included in Mr. Houthakker's data may include more than 2 adults, the difference is very small. One cannot, of course, infer very much from an estimate based on a free-hand curve. It would be interesting to see some serious estimates worked out, with their standard errors, and the results for different commodities collated.

On Mr. Houthakker's remarks about my own work I would make only a couple of comments. Before I decided to separate London families from the rest, I investigated the differences between the expenditure patterns of households in all the main (Ministry of Labour) regions. It was immediately obvious from this comparison that the differences between London and any other region were much greater than the differences between any two of these other regions; the items mainly concerned were rent, travel and clothing. Secondly, the correlation which is likely to exist between the average age of children and the family's income would not affect the estimated expenditure on children at the average standard of living, which was all that I was after.

This evening's paper, like one or two others which have been presented to the Society recently, falls into the category of "work in progress". When I come across elliptical remarks on points that are not immediately obvious, followed by a footnote promising to explain the point in some future publication, I cannot avoid a childish feeling of irritation. We have enjoyed an excellent plate of *hors d'oeuvres*, and it seems a pity that we shall have to wait some time before the main course is served.

I would now like to propose a warm vote of thanks to Mr. Houthakker for his extremely interesting paper, which comes, as it happens, at a very opportune moment. It should be very useful not only in planning, but also in analysing the results of the new family budget survey which has been promised.

Dr. W. R. Buckland: It gives me great pleasure to second the vote of thanks to Mr. Houthakker, and to express my regard for the spirit of optimistic construction with which the Department of Applied Economics at Cambridge pursues the difficult statistical problems it has chosen to investigate. Mr. Houthakker tells us that his paper should be regarded as a preface to a forthcoming addition to the Department's series of monographs. I am sure he would not wish the imminence of this larger work to restrict the discussion on the paper now before us, but I think this should be borne in mind and shall therefore restrict my own comment to matters of general interest.

In the first place, I, too, should like to draw attention to the essentially co-operative nature of the research, both with regard to men and to materials. Team research is now almost synonymous with "good" research in the sense that many worth-while problems of the present day are so complex that they are beyond the capacity and organization of the lone scholar.

Secondly, I would comment upon the essentially practical character of the paper; indeed, of the whole stream of inquiry of which it is but a part. I trust that its themes of "to find out" and "how to go about it" will help coming generations who wish to study examples of what may be achieved by the capable use of advanced methods.

Thirdly, I would refer to the various difficulties encountered during the analysis of the data under review, for example, the problem of household income in para. 2.2 and of regional analysis in para. 2.4. These are further examples of the need for design in the collection of economic statistics—a need often expressed in this hall and also voiced by Mr. Stone in his Newmarch Lectures of 1948–49, and of which happily, there now seems to be a greater official awareness.

The particular field of statistical analysis before us contains many pitfalls for the unwary. Unlike Mr. Nicholson, I have no special experience in this field, but as a potential user of the results I wonder whether the various sub-samples of households used for detailed analyses are

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valid or representative. I can trace no direct assurance on this point in any of the available papers; perhaps Mr. Houthakker could offer some guidance. In any case the data represent the social life of an almost bygone age and without considerable adjustment the results cannot easily be pressed into current use.

The results of particular interest to me are those for London—especially those in connection with expenditure on transport services. In para. 1.3.4 Mr. Houthakker states that "Family size, occupation and location are no doubt the three main factors on the preference side which make for differences in consumption". I think he would agree that, just as size should be interpreted in terms of composition, location should include the kind of dwelling occupied by the household. At all events these factors are likely to exert strong pressure on the demand for travel. Although no detailed statistical evidence is at present available, it is a common observation that crowded dwellings in and around an industrial area decrease the need for passenger transport services for the journey to work. On the other hand, a large metropolitan area with dormitory suburbs produces the kind of results given in the tables attached to Mr. Houthakker's paper. I think that in this respect London households are distinctly different from those in any other part of the country. If there is a high proportion of flatted dwellings or of dwellings without gardens there will probably be an enhanced demand for passenger transport services for recreational journeys. Again, if there is an area where domestic service is still extensively used the demand for off-peak travel will be greater than it might otherwise be. Yet again, a housing situation where a middle-aged couple live in their own house with a garden and a young household with children live in a block of flats will tend to promote a greater demand for travel facilities than if the positions were reversed. In future inquiries I should like to see the type of house and its immediate recreational facilities included in any consumer budget survey.

My final point concerns the problem of the supplementary earner who contributes to the household income raised by Mr. Houthakker in para. 2.3.0 and in sect. 8. My limited experience has shown that this is a most important aspect, and one scarcely appreciated by many of those who use this kind of information in the ordinary course of business as distinct from statistical research. Anything that Mr. Houthakker can do towards revealing the position of the supplementary earner would be most acceptable.

I assure Mr. Houthakker that we shall await the full monograph with great interest.

The vote of thanks was put to the meeting and carried unanimously.

Mr. GEORGE MORTON referred to a point which was of special interest to him, viz., that of unit consumer scales. He thought the author would agree that so far no satisfactory scales existed. If, however, food consumption only was considered, such scales could be constructed by taking minimum expenditures (for given prices) necessary to satisfy specified nutritional requirements. The "adult male" scales could then be found as the minimum expenditure for women and for children of various ages compared to that of men. This standardization contained, of course, a normative element; it also raised problems of defining physiological requirements and of the accuracy of the nutrient breakdown obtainable from food tables, but he thought that further efforts along the lines of "objective" needs should be made. In particular he would like to stress the importance (*a*) of making an adequate nutritional analysis of foods consumed whenever *budget* inquiries were made, and (*b*) of including prices in surveys of *nutrition*, since published data lacked one or other of these details.

Mr. AINSWORTH said that the Ministry of Labour analysis showed that there were differences in patterns of consumption and preferences in different regions of the country, and calculations on a regional basis, for which material was available for working-class households, should be interesting. For example, home-made bread was favoured in the northern counties, thereby cutting down the expenditure on bread to one-half of what it was in the rest of the country, with a corresponding increase in expenditure on flour. The consumption of butter and margarine, again, was different in the south-east from the rest of the country. There were also differences in the preference for home-killed or imported meat. It would be interesting and useful to see whether these local preferences were maintained at the various income levels. The size of the household also showed some regional variations. The regions of England and Wales showed little variation, but in Scotland the average size of household was 8 per cent. above that in England and Wales, and in Northern Ireland over 25 per cent. above. Dr. Buckland had referred to the possible effects of a supplemental wage earner in the household. There might or might not be something in that point, and it would be interesting to have it examined. The pattern of expenditure might be found to be different even within the same income group, as between households with one wage-earner and those of the same size with two or more wage earners.

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Mr. W. J. CORLETT was not convinced that the division between specific and income effects was of much value for econometric analysis. The author rejected any interpretation involving compensating variations or utility considerations, but without such an interpretation the division between the effects became blurred and depended on one's views of the items likely to have specific effects.

The principal use made of the division was in section 5.1.4 in the "intuitively obvious" argument, which, however, seemed far from obvious. The mathematical argument did not appear to make any direct use of the division. Incidentally, with the type of Engel curves taken for this argument, the influence of an increased number of children on the net effect of an additional child was identical with the influence of a certain decrease in total expenditure. Thus the conclusion that the more children the smaller the net effect was simply a restatement of the assumption that the larger total expenditure the greater the net effect.

He asked the author to elaborate his remark in section 2.7 that there was a close theoretical connection between cross-price elasticities and the intercorrelations of expenditure of different families on different items at the same prices. He did not see how any relationship could be obtained without some rigid and arbitrary assumptions about how tastes differ from one family to another.

In section 5.3.0, when discussing non-linear Engel curves, the author gave a rule for the variation with income of the weight of a category of person in the income scale. It depended on the correlation of the weight in specific scales with income elasticity. If this rule were applied to linear Engel curves, where income elasticity was not necessarily equal for all items, there would be a variation of the k_i's with income in that case also. He thought that the rule should be framed in terms of the variation of the b_j's with income.

Finally the author explained the large percentage differences attributed to a child in children's clothing to the fact that childless households spent very little on the item. Several of the childless households presumably recorded no expenditure on children's clothing. If that were correct, he wondered how these households were dealt with in a regression analysis which used the logarithm of expenditure on the item as one of the variables. The explanation seemed to be that the problem was evaded by the use of grouped data. From the results on quality variations it would appear that about 50 groups were used. Could the author say whether this was right and, if so, whether the same number of groups was used in other calculations. The interpretation of the results—in particular of R^2—clearly depended on whether the calculations were based on the original data or on averages. In addition it should be made clear that the form of regression equation used could not apply to data for individual families.

Professor CHAMPERNOWNE agreed with Mr. Nicholson's defence of the fitting of Engel's function of the quadratic form $y_i = a_i + b_i x + c_i x^2$, where x = total expenditure and y_i = expenditure on a given commodity C_i. Mr. Houthakker's objection that b_i and c_i would be intercorrelated could be met by using orthogonal polynomials and writing

$$y_i = a'_i + b'_i (x - \bar{x}) + c_i \left\{ (x - \bar{x})^2 - \frac{m_3}{m_2} (x - \bar{x}) - m_2 \right\},$$

where $\bar{x}$ is the arithmetic mean value of x and m_2 and m_3 are the second and third moments about the mean of the distribution of x. In this case the coefficients b'_i and c_i would be uncorrelated.

If attention were confined to the range of x for which observations had been collected then it was likely, as Mr. Nicholson had pointed out, that the fitted values of y_i would be positive. Thus within that range the additivity condition $\sum_i y_i = x$ could be exactly satisfied if the y_i were quadratics in x.

Mr. Houthakker claimed that the additivity condition would be approximately satisfied if the y_i were fitted by exponential equations $y_i = \beta_i x^{\alpha_i}$ but this was questionable: for let $\frac{\Sigma y_i}{x} = \varphi(X)$ where $X = \log x$ then

$$\frac{d^2\varphi}{dX^2} = \frac{1}{X} \sum_i (\alpha_i - 1)^2 \, y_i > 0$$

which showed that φ consistently had appreciable positive curvature w.r.t. X since the elasticities α_i were known to be scattered widely about the value unity. This was inconsistent with the approximate satisfaction of the additivity condition, which could be rewritten as $\varphi(X) \equiv 1$ for all X.

Professor Champernowne did not attach very great importance to the additivity condition, and it was true that so soon as one attempted to extrapolate the quadratic formulae beyond the

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range of x covered by the data one would be likely to encounter negative values of the fitted y_i: but a similar objection could be made against Mr. Houthakker's formulae $y_i = \beta_i x_i^{\alpha_i}$ for in the case of luxuries for which $\alpha_i > 1$, this formulae would imply $y_i > x$ where $x > \beta^{1-\alpha}$. Hence, just as the quadratic formulae, Mr. Houthakker's formula also must be misleading if exterpolated to large values of x.

It was tempting to suggest other formulae for Engel's curves in place of the quadratic and exponential formulae. There were considerable advantages in choosing from among formulae of type

$$\frac{y_i}{a_i} = f\left(\frac{x_i}{b_i}\right)$$

containing just the two scale parameters b_i and a_i and where f was a function yet to be chosen. Any formula of this type could also be written in the form $Y_i - A_i = F(X - B)$ where Y, A, X and B denote the logarithms of y, a, x and b. The form of the function f, and hence also of F, having once been chosen, A and B could then be fitted to the data by the obvious graphical method.

[Professor Champernowne wrote later to say that if graphical methods were disliked, maximum likelihood solutions for a and b could quite easily be found to any required degree of accuracy provided that the error distribution for either y or $\log y$ was assumed to be normal.]

Bearing in mind the economic considerations governing the form of Engel's curves, the choice for the function f which had occurred to Professor Champernowne was—

$$f(z) = 1 - e^{-z} \text{ for necessaries,}$$

$$f(z) = z^{\frac{1}{z}+1} \text{ for luxuries.}$$

This choice implied that there was a ceiling expenditure on any necessary good, and that as total expenditure fell the proportion of it devoted to each necessary good rose: the proportion of expenditure devoted to each luxury good settled to a constant when total expenditure became large, but sank to zero as total expenditure became small.

The additivity condition could not be exactly satisfied by these formulae but the discrepancies involved were not nearly so serious as in the case of the parabolic and exponential formulae already discussed. It would be interesting to fit the new formulae to the data, since the suitability of suggested formulae could not be decided *a priori* but depended partly on how well they fitted available facts.

Mr. Robert Summers criticized the procedure utilized in estimating the parameters of the regression equations, pointing out that the Method of Least Squares applied separately to each member of a set of simultaneous equations would in general give biased estimates at best and meaningless estimates of unidentified parameters at worst. The difficulty here arose out of the fact that total expenditure, treated as an independent variable in each equation, was not really independent of the stochastic variables except under some arbitrary economic hypothesis. Just what kind of economic behaviour would be implied by the assumption of independence in Mr. Houthakker's logarithmic relations would be difficult to establish. The point could be illustrated, however, for the case where the regression equations were linear. Then on the somewhat questionable assumption that the consumer's income was not affected by his consumption, independence would require that the sum of the stochastic terms in the various equations be equal to zero. This would imply that though a consumer with a specified income would occasionally buy less or more of a particular commodity than his budget called for, he would always spend the same total amount of money; i.e., "errors" in purchasing particular commodities would always be balanced by "errors" in purchasing other commodities, savings being unaffected by these deviations from the budget. *A priori* it appeared more reasonable, however, that savings would be an important, if not a principal, buffer in compensating for the deviations. For technical reasons related to the non-existence of a preference function which would give the specific kind of relation Mr. Houthakker used, the speaker could not state what assumptions regarding the consumer's behaviour would be necessary in order to rationalize Mr. Houthakker's estimation procedure.

Mr. T. C. B. Watson referred to the income classification used in the Civil Service Middle Class Cost of Living Enquiry as covering "the earned and unearned income of the head of the family but not the income of the wife or other wage-earners. Income should include any sum deducted at source for income tax, superannuation, insurance, etc. Income should not include payments from one member of the household to the head".

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With reference to prices, a subsample of some 200 families had been investigated. The data covered some 40 items of foodstuffs, coal, coke and tobacco, and was classified by income only. By comparing the average prices paid by middle class families for foodstuffs included in the Ministry of Labour's cost of living Index Number, a quality differential of 10 per cent. between middle class and working class was indicated.

Mr. HOUTHAKKER thanked the speakers for the thoroughness with which they had read and commented on his paper. He was glad a number of speakers had referred to the co-operative nature of this type of inquiry, which to him had been one of its most interesting aspects.

He subsequently replied in writing as follows:

The question of the shape of Engel curves (Section 3 of the paper) has turned out to be the main subject of discussion. My remarks were intentionally brief in view of Mr. Prais's researches referred to in the text, which survey the empirical evidence in greater detail and may lead to a further revision of opinions. The necessity of taking into account heteroscedasticity has just recently been stressed also by Klein and Morgan (*J. Amer. Stat. Ass.*, **46** (1951), p. 442–460), although they do not consider the use of double-logarithmic Engel curves* for that purpose. The support which my remarks on additivity have found does not detract from the interest of Professor Champernowne's convexity condition.

Mr. Corlett has pointed out an omission in my discussion of double-logarithmic functions, viz., the problem of zeros. This difficulty is not always eliminated by grouping, and the common practice is to replace a zero observation by a small positive number. This number should not be too small, however, for otherwise zero observations would get an unduly heavy weight, their logarithm thus becoming large and negative. There is clearly scope for theoretical consideration of this problem, which may be serious if ungrouped data are used.

The number of expenditure-size groups on which the regression analyses in the main inquiry are based is 56 for working-class and 42 for middle-class households (a few of these are empty). This does not apply to Table 1, for which Mr. Nicholson's original classification was used (cf. also 8.1). Correlation coefficients based on grouped data have only comparative significance, but the standard errors, which are in any case the more important indicators of reliability, are approximately invariant under grouping.

My objection to quadratic Engel curves was really that the increased flexibility due to the quadratic coefficient is largely spurious because of the covariance between b and c (in Professor Champernowne's notation), though b' and c are of course independent. From Professor Champernowne's further discussion I infer that he also thinks that two coefficients should be enough. At the moment I do not see how maximum-likelihood estimates of the parameters in his general formula can always be obtained by explicit solution.

Mr. Summers has raised an important point, but its discussion must inevitably be vague: even if there is correlation between individual expenditures and total expenditure the extent of the bias is not known. If each of the individual items is small compared to the total this bias could hardly be serious. The use of total expenditure instead of income in the present inquiry was unavoidable for technical reasons, but it might even be preferable where income figures are available because the latter are subject to notorious difficulties of interpretation. It can incidentally be shown that the introduction of the sum of the dependent variables as an explanatory variable does not affect the validity of least-squares methods if this sum is regarded as fixed.

I hope that a re-reading of section 5.4.3 will convince Mr. Corlett of the usefulness of the distinction between specific and income effects of family size. His two objections to the argument in 5.1.4 that it is "far from obvious" and that "the conclusion [is] merely a restatement of the assumption" seem to cancel each other. He is right in stating that specific effects can only be studied if we know in which items they will show up, but this is equally true if we invoke a utility interpretation. I agree that the rule in 5.3.0 is loosely worded and should be reformulated as Mr. Corlett suggests.

As section 2.7 was inserted mainly to warn other students off a possible red herring, it does not seem worth while to set out the relevant relationships in full. The assumption was that the coefficients bi (in the notation of Allen and Bowley (1935), pp. 136, 140) are normally and independently distributed between individuals. I do not think this assumption is excessively rigid or arbitrary, but it does not appear to lead to anything useful.

* I prefer to call curves as defined in 3.8 by that name and to reserve the designation "exponential" for functions where the independent variable occurs in the exponent, as is the case with the two formulae suggested by Professor Champernowne.

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In principle one may sympathize with Mr. Morton's call for the introduction of "objective" elements in the analysis of family size effects, but unfortunately the few available efforts along those lines led to results that bear little or no resemblance to actual expenditure patterns. Thus the money cost of a physiologically adequate diet is found to be very small compared to actual outlay on food. The similarity which Mr. Nicholson notes between the results of his and my researches on income effects of family size is very reassuring; it provides further evidence that the use of total expenditure per head may be satisfactory as a first approximation to the "true" income scale.

Dr. Buckland's and Mr. Ainsworth's remarks on regional variations (including those within towns) and supplementary earners suggest further analyses, most of which are in fact possible with the cards already punched. These cards will be available to other investigators should the Department of Applied Economics be unable to undertake these analyses itself.

The question of representativity, raised by Dr. Buckland, is one of undoubted importance to the user of family budgets. It should be realized, however, that in this and other papers on the analysis of household surveys only "internal" evidence is considered, whereas a study of representativity requires a quite different approach, involving a comparison with other sources of information. The discrepancies in the case of drink and tobacco are of course well known. For the rest my own limited experience did not bring to light any major discrepancies between the two pre-war surveys and other data from the same period if their restricted coverage is taken into account (cf. also this Journal, Series A, **114** (1951), p. 368).

Mr. Watson's clarifications on the middle-class survey are very valuable. We were not aware of the existence of quantity information for this survey; it might lead to interesting comparisons with the working-class budgets.

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Brian Adkins.
Maria Luiza de Alzavedo Amaral.
Paul L. Anastassiades.
John Everett Andrew.
Cecil Gardner Baird.
Rennie Barker.
Stephen Kenneth Beer.
William Alfred Bennett.
Harold Geoffrey Berrisford.
Raj Chandra Bose.
Keith Tudor Boyd.
Alfred Bunting.
Arun Kumar Chatterjie.
Seng Chew Chua.
Lionel Cohen.
Christine Curran.
Glyn James Davies.
Thomas Peter Dettering.
Rolando F. Duarte.
Bernard Edwards.
David Brenig Edwards.
S.S. Nour Eldin.
Elaine Rosemary Fitch.
Robert Redvers Follett-Smith.
Melville Denis Joseph Gellard.
Ian Frederick Hendry.
George Hayward Holder.
Louis Honoré.
William Robert Humphreys.
Stanley Frank Isaac.
Edward Ronald Knapp.
John Lane.
Kenneth Frederick Lane.
John George Langston.
Ernest Harry Lever.
Sheila Yvonne Mallett.
Kurt Mannaberg.
Léopold Martin.
José Maria Pompeu Memoria.
Bernard Francis Middleton.
Ewan Stafford Page.
Basil Philip Pain.
John Harry Parkinson.
Gwilym Herbert Peregrine.
Bruce Ian Pilley.
Alan Richmond Prest.
Ronald Lewis Prevett.
Edward Akufo Quist-Arcton.
Philip Edward Râtel.
William John Reeve.
Louis Rosenberg.
Kinichiro Saito.
Colin Ernest Kerr Scouller.
Peter A. Stone.
Joseph Frank Swain.
Jan Szlichter.
Pricha Thaiarry.
John Mervyn Timmons.
Mirjana Cherry Vidakovic.
Frank Christopher Waddams.
Ke-Ching Wang.
Frank Herbert Westbrook.
Michael Horatio Westmacott.
Margaret Rosamund Wheatley.
Sir Reginald Wilson.
Eric Arthur Woodroof.
Barnet Woolf.
S. M. Zia-I-Ghaus.

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The Interdependence of the British Economy

By T. Barna

[Read before the Royal Statistical Society, December 19th, 1951, the President, Professor A. Bradford Hill, C.B.E., in the Chair]

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1. *Introduction*

1.1. The practical purpose of economics is to be able to forecast the economic results of decisions in order to lay before those responsible for choice the consequences of alternative actions. A businessman might like to know to what extent the volume of his sales would be reduced if he raised price by 10 per cent.; or he might like to know how much he would add to his costs if he expanded output by 5 per cent. A government department might be interested in knowing the level of subsidies necessary to induce the building of 200,000 houses in a year; or it would wish to know the amount of labour and different kinds of materials required for the building of that number of houses. The central concern of economics—in this respect more properly called by the old name of political economy—is, however, not with the consequences of private or sectional decisions but with those of public policy. The national economy has certain broad aims, which may be pursued simultaneously or as alternatives, such as a high level of employment, avoidance of inflation, balance in its foreign payments, an adequate production for defence purposes, or a

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The Interdependence of the British Economy

By T. Barna

[Read before the Royal Statistical Society, December 19th, 1951, the President, Professor A. Bradford Hill, C.B.E., in the Chair]

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1. *Introduction*

1.1. The practical purpose of economics is to be able to forecast the economic results of decisions in order to lay before those responsible for choice the consequences of alternative actions. A businessman might like to know to what extent the volume of his sales would be reduced if he raised price by 10 per cent.; or he might like to know how much he would add to his costs if he expanded output by 5 per cent. A government department might be interested in knowing the level of subsidies necessary to induce the building of 200,000 houses in a year; or it would wish to know the amount of labour and different kinds of materials required for the building of that number of houses. The central concern of economics—in this respect more properly called by the old name of political economy—is, however, not with the consequences of private or sectional decisions but with those of public policy. The national economy has certain broad aims, which may be pursued simultaneously or as alternatives, such as a high level of employment, avoidance of inflation, balance in its foreign payments, an adequate production for defence purposes, or a

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programme for modernizing industrial equipment, and the task of economics consists in the formulation of mutually consistent policies leading to these aims, within the assumed framework of institutions and with due respect to the implicitly assumed major aim of maximizing consumers' welfare. For this purpose it is necessary to examine the internal consistency of private and sectional decisions, as well as the consistency of these decisions in the aggregate with the broader aims of society. For instance, coal mines may plan to produce a certain amount of coal for sale to industry, at a price determined by their customary pricing methods, on the assumption that oil prices will not change; but these plans will be frustrated if oil companies are planning to reduce price in order to expand sales. Or, the investment programmes of industries in the aggregate may require more steel than the steel industry is planning to produce. Lastly, consumers, business and government in the aggregate may want to spend more than the value of the likely amount of production at existing prices, and hence they may cause a general rise in prices, which is against the aims of public policy.

Economic Interdependence

1.2. The difficulty in a study of economic relationships is the fact that, it is impossible to isolate any single relationship, as can be done in most other sciences. The steelmaster, for instance, fixes his price, taking into account the existing or expected price of coal; but the price of coal is influenced by the prices of structural steel, of steel tubs and rails, of machinery, and of railway equipment, all in their turn dependent on the price of steel. The government may tax consumption in order to finance an investment programme, calculated on the basis of current or expected wage rates; but higher taxes might lead to claims for higher wages, thus reducing the volume of investment which the proposed tax would finance. The high degree of interdependence of the economy implies that general equilibrium can be determined only with reference to a very large number of simultaneous equations, each containing a very large number of variables, and the empirical application of this method would clearly be unmanageable. Hence, instead of aiming at general equilibrium analysis, empirical research has been following two paths: one was the analysis of demand for or supply of particular commodities, and the other the analysis of national income by its main components, such as consumption and investment; the first type of analysis is detailed but only partial, and the other is general but aggregative.

1.3. The best examples of partial equilibrium analysis, those using multiple correlation techniques on time series or family budgets to determine demand or supply functions, can be relied upon to give useful results only so long as the number of relevant variables to be considered is small and is not connected by more than one functional relationship. This means that in practice such analysis is confined to the demand for consumers' goods or the supply of raw materials, and even in these fields its applicability is restricted. If the task is to analyse demand for raw materials or intermediate goods which can be used for several purposes, the method of partial analysis breaks down, since demand depends not only on price but also on the whole structure of the economy, that is, on too many variables to be considered by this type of analysis. And equally, the method breaks down if it attempts to analyse the supply of consumers' goods, since price is a function not only of quantities supplied, but also of all other supply relationships at the raw material and intermediate stage. Exceptions may, of course, be found where partial equilibrium analysis can be successfully applied to the demand for raw materials or the supply of consumers' goods, but, equally, exceptions can be found when that analysis breaks down in the case of demand for consumers' goods or supply of raw materials; in the instance when price is closely related to income, either because income is a cost element or because price is a cost-of-living element, it is no longer possible to separate in a reliable form the effects of price and of income on demand or supply.

1.4. National income analysis, on the other hand, deals with significant aggregates, such as total consumption, investment or saving, and their relationships, and hence loses important detail and thereby leaves its own validity resting on tenuous assumptions. The stability of the relationship between, say, national income and saving lasts only so long as the distribution of incomes remains unchanged. The deficiencies of national income analysis are most serious when its subject is the transference of resources from one purpose to another, such as, for instance, an increase in defence production at the expense of consumption; from national income analysis itself it is not possible to tell what changes in the structure of the economy are required to bring

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about such an adjustment. It is not disclosed where strains will arise in the economy and in which direction policy ought to move. Does more defence production and a balanced cut in consumption in general increase or decrease the demand for steel or for textiles? Can a switch from private to public investment take place without a change in the structure of industry? These questions remain unanswered.

A Study of Structural Relationships

1.5. The purpose of the present paper is to introduce a study dealing precisely with the structural relationships of the whole economy, the relationships with which partial equilibrium analysis is unable to deal but which, on the other hand, are beyond the scope of national income analysis. This statement of the nature of the study makes its advantages and limitations clear at the outset: it will be possible to discuss problems for which national income analysis in itself cannot give the answer, but the methods employed will have to be cruder than those used in partial analysis. For purposes of a study of structural relationships in the economy, economic relationships are considered in broad categories, the grouping being such that equilibrium can be worked out within any category without reference to the rest of the economy, but that the relationships to be studied are interdependent and cover the whole area of the economy. Thus the relationship between cotton spinning and cotton weaving is hardly interdependent with the rest of the economy, and consequently the cotton industry can be considered for most purposes as a single category; balance within the industry, between the spinning and weaving sections, can be established independently from a study of the economy as a whole.

1.6. General economic equilibrium is in the present paper conceived as consistency, in terms of commodities, in relationships between units making economic decisions: general equilibrium is reached if for each economic unit revenue and expenditure are in equilibrium (but not necessarily equal), and for each commodity entries into and clearances from the market are in equilibrium (but again not necessarily equal). The scope of the present study is more precisely defined by restricting it to the "real" structural relationships of the economy, which are determined by the pattern of demand acting on natural resources within the framework of a given technology, and by neglecting purely financial relationships. Hence economic units are defined in terms of physical activities which contribute to the processes of production and consumption, and the term "commodity" is confined to goods and services emerging and disappearing in the processes of production and consumption. Financial relationships are to a large extent in the nature of counterpart of the "real" relationships thus defined, and for this reason the two are often confused; financial relationships are based on ownership and not on physical activity; they run in terms of commodities in a wide sense, including titles to ownership, and extend to the transfer of ownership without counterpart transactions.

1.7. For a static and closed economy the application of these principles would be comparatively simple: the economy is divided into industries, corresponding to categories of activities in the process of production, on the one hand, and households and governmental agencies, engaged in the consumption of final products, on the other hand. In reality complications arise because of the existence of international trade and because of current production for future consumption (capital formation). The grouping of commodities corresponds to the grouping of industries, and incomes are taken to represent the participation in production of primary factors of production. Eventually a two-way table is obtained recording for each sector of the economy transactions in terms of commodities, that is, transactions with each other sector of the economy. This two-way table is first obtained corresponding to the actual position of the economy, and contains a complete record of flows of current goods and services between sectors of the economy during a given period.* This table is then used as the basis for answering certain questions. What will be, for instance, the output of coal necessary for a given pattern of final demand? What will be the effect of a rise in the price of coal on all other prices? What are the relationships between wages in particular industries and the prices of particular commodities?

1.8. It might be argued that it is not essential to obtain answers to such questions by elaborate econometric models, since equilibrium can also be reached through trial and error: the price

* Flows *within* sectors are either not recorded or, if recorded, must necessarily be on an arbitrary basis, since their magnitude depends on the definition adopted for units within a sector.

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of coal is raised and this raises railway freights, which in its turn again raises the price of coal; all this raises the price of steel, which again reacts on the price of coal, and so on, in successively diminishing magnitudes, until the movement stops and equilibrium price relatives are again established. The practical advantages of being able to estimate the final rise in the price of coal and having one big increase instead of a succession of increases are, however, considerable. Moreover, if it is a question of making adjustments in accordance with a switch in the distribution of national expenditure, or to obtain reactions to a change in the terms of trade, a speedy knowledge of the new equilibrium position might become imperative, especially if capacity has to be expanded in industries where this requires a long period of construction.

1.9. The empirical study of economic interdependence in this form owes its origin, and to a large extent also its development, to W. W. Leontief. Originally (1936) he gave a statistical analysis for the United States in which inter-sector relations emerged as the product of a huge accounting system covering the whole country. Subsequently (1937, 1941) he formulated the theory of general economic equilibrium in such a way as to make it suitable for empirical application. In recent years the technique of equilibrium analysis advanced considerably in that direction, and became generalized to such an extent that it has become possible to apply it to the solution of problems other than inter-sector relations in an economy.*

1.10. The application of these techniques to the economy of the United Kingdom was begun soon after the war, and the present paper gives the first results of a larger study. It is restricted to a statistical evaluation of the actual flows of goods and services between sectors of the British economy in 1935. No comparison is made with other years or other countries, neither is the model obtained used for giving answers to particular problems; this is postponed for another time. Nevertheless, since the empirical model was prepared with a view to its eventual application to particular problems, its theoretical background and the statistical principles on which it is based will be set out systematically.

1.11. The next part of this paper contains a brief account of the theoretical framework of models showing inter-sector relationships. The third part indicates a number of problems to the solving of which these models can contribute, and discusses the statistical principles of application with reference to these problems. In the fourth part the model is applied to data for the United Kingdom in 1935, resulting in a table showing quantitative relationships between sectors. In the fifth part the limitations of the scheme adopted in relation to practical problems are enumerated and suggestions for further research are given.

2. *The Theoretical Model*

2.1. This part of the paper is concerned with the theoretical framework which has been found most useful for purposes of studying the interdependence of economic activities, and it is confined to a simple introduction to the subject more or less corresponding in scope to the statistical analysis which will follow in subsequent parts.†

2.2. An *activity* is defined as a homogeneous elementary process by which commodities (including labour) are combined to obtain other commodities. This definition can be somewhat restricted: the case of joint products may be regarded as a combination of activities, and hence the elementary process will be taken as one producing single commodities only. It seems trivial to add that an activity is a non-reversible process as, for example, labour and yarn can be combined to make cloth but cloth cannot be disentangled into labour and yarn. Since an activity is a homogeneous process, a given quantity of input uniquely determines all other inputs and the resulting output, and conversely, and hence substitution in the sense of having more of one input and less of another (whilst output remains the same) cannot take place. Substitution must be conceived, instead, as substituting one activity for another which produces the same commodity.

2.3. The definition of a commodity somewhat depends on the above definition of an activity. A commodity must be homogeneous, that is, one unit of it can be substituted for another unit of the same commodity, but no commodity can be substituted for another, in respect of any given activity. The homogeneity of a commodity thus depends on the number of activities, since

* Cf. in particular Wood & Dantzig (1949), and in general the work of the "linear programming" school in Chicago as represented by Koopmans, editor (1951).

† For a more advanced treatment cf. especially Koopmans (1951) and Goodwin (1950).

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with the introduction of additional activities (due to new inventions) it may be discovered that particular properties of one unit of a hitherto homogeneous commodity may not be possessed by another unit; as a matter of fact, the discovery of non-homogeneity in commodities usually leads to the invention of new activities. It is useful, from the point of view of terminology, to distinguish three kinds of commodities: primary, intermediate and final. Primary commodities cannot be produced by any known activity; final commodities are those commodities at the production of which the system aims, that is, it is considered better to have more of them; intermediate commodities can be produced by the system of activities but they are useful only as input in the production of final commodities.

2.4. In the simplest case it is assumed that an activity combines commodities in fixed proportions, that is, there are no economies or dis-economies of scale. Hence it is possible to express for each activity quantities of inputs (each in terms of its own unit) as coefficients per unit of output, and obtain actual quantities of inputs and outputs as the product of these coefficients and the scale of activity (where the unit of activity can be taken as producing one unit of output).

Two Examples

2.5. Two very simple examples will illustrate the nature of the economic problem considered here and the methods used in their solution; the mathematical solution in the case of the first example is not at all difficult, but in the case of the second example an insight is gained into the technical mathematical difficulties which would arise in a real economic problem.

2.6. Let us consider a system of four activities, those producing raw cotton, cotton yarn, cotton cloth and cotton dresses, where each activity uses the primary commodity, labour. The coefficients of the four activities are shown in Table 1, positive signs denoting input and negative signs output.

TABLE 1

Coefficients of Four Activities

	Activity producing			
Commodity	*Cotton*	*Yarn*	*Cloth*	*Dresses*
Cotton	−1	1·2		
Yarn		−1	1·1	0·1
Cloth			−1	4
Dresses				−1
Labour	0·5	0·2	0·3	0·4

2.7. According to the example, one unit of raw cotton requires 0·5 units of labour for its production, one unit of yarn requires 1·2 units of raw cotton plus 0·2 units of labour, and so on. Let us now assume that cotton dresses are the only final commodity, and find that combination of the four activities which is necessary for the production of cotton dresses; more precisely, let us find the equilibrium position of the system which would result, for the system as a whole, in the net output of one unit of dresses and in zero net output for each of the intermediate commodities. Quantities of inputs and outputs in equilibrium are shown in Table 2.

TABLE 2

Equilibrium between Four Activities

	Activity producing				
Commodity	*Cotton*	*Yarn*	*Cloth*	*Dresses*	*Net output*
Cotton	−5·4	5·4			0
Yarn		−4·5	4·4	0·1	0
Cloth			−4	4	0
Dresses				−1	1
Labour	2·7	0·9	1·2	0·4	−5·2

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2.8. Table 2 indicates "equilibrium" in the trivial sense of the term; rather it can be said that it gives the mathematical solution of the system. Four activities are connected through four intermediate commodities, and therefore the system is just determinate. Table 2 can also be regarded as a flow-chart showing the movement of commodities between sectors; although the figures were shown for one unit of net output of dresses, for any other quantity of net output of dresses it is only necessary to change all of them proportionately. The system is in equilibrium if 5·4 units of cotton, 4·5 of yarn and 4 of cloth are produced for each unit of dresses. It is also found that 5·2 units of labour are cumulatively required for the production of one unit of dresses, distributed between the four activities in the ratio of 2·7 : 0·9 : 1·2 : 0·4. The four activities are interdependent, since the scale of one determines the scale of all other activities for the system to be in equilibrium, but the interdependence is such that there is no "feed-back" in the system, that is, the output of later stages of production is not used as the input of earlier stages. More strictly stated, it is possible to arrange Table 1 in such a way that all input coefficients should fall to the same side of the diagonal given by the output coefficients; it was this fact which made the arithmetic of the solution obviously easy.

2.9. The above example illustrated relationships within a given sector of the economy rather than relationships between sectors, and was of interest more from the engineering than from the economic point of view. The economic system as a whole is interdependent in a more complicated manner, and in a more realistic example activities use each other's output as input. Let us, for instance, consider three activities, those producing coal, steel and machinery, where each activity uses the primary commodity, labour. The coefficients of the three activities are shown in Table 3.

TABLE 3

Coefficients of Three Activities

Commodity	*Activity producing*		
	Coal	*Steel*	*Machinery*
Coal	−1	2	0·2
Steel	0·1	−1	0·5
Machinery . . .	0·1	0·3	−1
Labour	0·5	0·3	1

2.10. Here each activity uses, in addition to labour, the output of all other activities as input. Let us assume that any of the intermediate commodities can also be a final commodity, and find the equilibrium position which would result in, for example, one unit of net output for machinery but none for the other commodities. The solution could be obtained by a lengthy method of trial and error, arriving at successive approximations to the correct solution, or—more efficiently—by the use of simultaneous linear equations. Writing c, s and m for the output of coal, steel and machinery respectively, equilibrium requires the following:

Zero net output for coal, i.e., $c - 2\,s - 0{\cdot}2\,m = 0$
Zero net output for steel, i.e., $-0{\cdot}1\,c + s - 0{\cdot}5\,m = 0$
Unit net output for machinery, i.e., $-0{\cdot}1\,c - 0{\cdot}3\,s + m = 1$

Solving this system of equations, and applying the input coefficients, we obtain the flow-chart given (to 2 decimals only) in Table 4.

TABLE 4

Equilibrium between Three Activities

Commodity	*Activity producing*			*Net output*
	Coal	*Steel*	*Machinery*	
Coal . . .	−2·31	2·00	0·31	0
Steel . . .	0·23	−1·00	0·77	0
Machinery . .	0·23	0·30	−1·53	1
Labour . .	1·15	0·30	1·53	−2·98

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2.11. The net output of one unit of machinery thus actually requires the output of 1·53 units of machinery to allow for "feed-back" of machinery into "earlier" processes of production. Of the corresponding output of 2·31 units of coal most is used in steel-making and some in making machinery, whilst of the output of 1·00 units of steel most is used in the production of machinery but some also in coal-mining. To obtain a net output of one unit of machinery the system uses cumulatively 2·98 units of labour, distributed between the three activities in the ratio of 1·15 : 0·30 : 1·53. So long as a net output of machinery only is required these ratios remain unchanged, but if the system is asked to produce net output of coal or of steel, or of a combination of commodities, the distribution of labour and the whole structure of activities will have to be different.

General Form

2.12. This system can be generalized, retaining the assumptions adopted hitherto, which were the following:

(i) There are $n + 1$ commodities, of which only one, the $(n + 1)^{th}$, is a primary commodity.

(ii) There are n activities, where each activity produces only one commodity, and at least one activity uses the primary commodity as input.

(iii) For each activity input-output ratios are constant.

2.13. Let us write $x_1, x_2, \ldots x_n$ for the output of the first, second, . . . and n^{th} commodities respectively, and $y_1, y_2, \ldots y_n$ for the net output, by the system of activities as a whole, of the same commodities. In respect of the jth activity, let us write $a_{1j}, a_{2j}, a_{nj}, b_j$ for the input coefficients (where $a_{jj} = -1$) of the first, second, . . . n^{th}, and $(n + 1)^{th}$ commodities, the last being the primary commodity.

Equilibrium is defined by a set of n linear equations:

$$\sum_j a_{ij} x_j = -y_i, \quad j = 1 \ldots n; \quad i = 1 \ldots n. \qquad (1)$$

2.14. Let us write* $A \equiv [a_{ij}]$, $i = 1 \ldots n$, $j = 1 \ldots n$, for the matrix of input-output coefficients, omitting the coefficients for the primary commodity; x for the column-vector $\{x_1 \ldots x_n\}$; and y for the column-vector $\{-y_1 \ldots -y_n\}$. In matrix notation then

$$Ax = y, \qquad (2)$$

and hence

$$x = A^{-1} y. \qquad (3)$$

A^{-1} is the reciprocal matrix of A, whose $(i, j)^{th}$ element is $\frac{|A_{ji}|}{|A|}$, where $|A_{ji}|$ is the co-factor of a_{ji} in the determinant $|A|$.
For instance,

$$x_j = \sum_i \frac{|A_{ji}|}{|A|} \cdot -y_i, \quad i = 1 \ldots n; \; j = 1 \ldots n. \qquad (4)$$

The aggregate input of the primary commodity is easily given by

$$C = \sum_j b_j x_j, \quad j = 1 \ldots n. \qquad (5)$$

2.15. The equilibrium solution has been found in a strictly technical sense, that is, on the basis of the technical relationships of the economy. It is also necessary to obtain equilibrium in the financial sense, by equating the receipts and expenditures of each activity. Writing $p_1, p_2, \ldots p_n, w$ for the unit prices of commodities (the last being the primary commodity), equilibrium is further defined by the following set of n linear equations:

$$\sum_i a_{ij} p_i = -b_j w = -v_j, \quad i = 1 \ldots n; \; j = 1 \ldots n, \qquad (6)$$

where v_j is the value of the primary commodity per unit of output (e.g., labour cost).

2.16. Let us write $A' \equiv [a_{ji}]$ for the transpose of matrix A; p for the column vector $\{p_1 \ldots p_n\}$; and v for the column vector $\{-v_1 \ldots -v_n\}$.

* Throughout the terminology and notation of Aitken (1949) are used.

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Similarly to equations (2) and (3) we have

$$A' p = v \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

and hence

$$p = (A')^{-1} v. \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Writing p' and v' for row vectors containing the same elements as p and v respectively,

$$p' = v' A^{-1}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

For instance

$$p_i = \sum_j \frac{|A_{ji}|}{|A|}. \quad - v_j, \qquad j = 1 \ . \ . \ . \ n; \ i = 1 \ . \ . \ . \ n. \quad . \quad (10)$$

2.17. Equations (3) and (9) exhibit a certain symmetry through containing the reciprocal matrix A^{-1}. If columns of that matrix are multiplied by net outputs (y_i), the sum of rows obtained will give outputs (x_j), provided that the elements of the matrix were written with a positive sign; if rows are multiplied by unit costs of the primary commodity (v_j), the sum of columns obtained will give prices (p_i). Therefore if the columns of the reciprocal matrix A^{-1} are multiplied by net outputs and the rows of the resulting matrix by unit costs of the primary commodity, the sum of each row will give the aggregate cost of the primary commodity for each activity and the sum of each column the value of net output for each commodity.

$$\bar{v} A^{-1} \bar{y} \{1\} = \{vx\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

and

$$\bar{v} A^{-1} \bar{y} [1] = [py], \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

where v and $\bar{y}$ are diagonal matrices consisting of the same elements as v and y respectively; $\{vx\}$ the column vector of elements vx and $[py]$ the row vector of elements py, and $\{1\}$ and $[1]$ the unit vectors.

Multiplying equation (4) by v_j, and equation (10) by y_i, we obtain respectively

$$v_j x_j = \sum_i \frac{|A_{ji}|}{|A|} \ . \ - v_j y_i, \quad . \quad . \quad . \quad . \quad . \quad (13)$$

and

$$p_i y_i = \sum_j \frac{|A_{ji}|}{|A|} \ . \ - v_j y_i. \quad . \quad . \quad . \quad . \quad . \quad (14)$$

It will be noted that the net output of the system (national income) can be obtained by summing the column totals (value of final commodities) and this is equivalent to the sum of row totals ("value added" by activities).

2.18. The system, as shown in equations (11) and (12), consists of two sets of variables and a set of parameters. These are:

(i) Values of net output for each commodity;
(ii) "Value added" for each activity;
and (iii) The matrix A^{-1}, that is, the reciprocal of the matrix of input-output coefficients (other than the coefficient for the primary commodity).

Hence the system can be used to solve the following problems:

(*a*) With given matrix A^{-1}, find the set of added values for a new set of net output values, or
(*b*) find the set of net output values for a new set of added values.
Or (*c*) with a given set of net output values, find the set of added values for a new matrix A^{-1}, or
(*d*) with a given set of added values, find the set of net outputs for a new matrix A^{-1}.

2.19. It will be noted that the input coefficients for the primary commodity (e.g., man-hours per unit of output) are incorporated in the set of added values and not in the matrix A^{-1}. Hence a change in these coefficients will fall under problem (*b*), but a change in other input coefficients under (*c*) or (*d*). It was evident from equation (3) that a change in the set of coefficients for the primary commodity (b_j) has no repercussion on the structure of output; the pattern of primary

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input would of course change. The effect of a change in the coefficients for the primary commodity, as shown by equation (9), changes the set of prices only.

2.20. Further, it is superfluous to assume (except in certain special cases) that the price of the primary commodity is the same in respect of each activity. We can assume in respect of a given activity a price, w_j, independent of the price relevant for other activities, because only $v_j = b_j w_j$ (that is, the value of the primary commodity per unit of output) is the variable considered by the system. It can be easily seen that a fall in w_j has exactly the same effect on the structure of prices as a proportionate fall in b_j; in other words, the results on prices of a fall in wages in a particular industry are identical to the results of a proportionate rise in the "productivity" of labour.

2.21. Although the exposition is much simpler in terms of only one primary commodity, it is apparent that any number of primary commodities can be considered. The method by which the of input of one primary commodity is obtained, can also be used to obtain the pattern for any other. As regards effects on prices, what matters is the change in the set of added values, irrespective of whether this is caused by a change in the price of one primary commodity or another, or of whether the input coefficient of one or the other changes. If one deduces a set of added values, however, the system of equations leaves it open how these values are to be distributed between the different primary commodities. It is also to be noted that the structure of industry which is the ideal in respect of a given total quantity of one primary commodity may require more or less of another primary commodity than the total to be allocated (resulting in one or the other becoming to some extent "unemployed").

2.22. It should be also noted that the set of input-output coefficients must be consistent with net outputs emerging from the system. The fact that all outputs, net outputs, prices and unit labour costs must be non-negative imposes a restriction on the set of values the matrix of input-output coefficients can assume. This restriction is, however, met if each element in the reciprocal matrix A^{-1} is non-negative, which is the case of a matrix based on statistically observed transactions. It will be also obvious that if the set of coefficients can produce one pattern of output (or of prices), it can also produce any other pattern by a suitable rearrangement of the structure of activities (or the structure of wages).

3. *Statistical Application*

3.1. The essential difference between a mathematical model and its statistical application is that, whilst the mathematical model is running in terms of a finite number of independent variables (commodities) and processes (activities), in reality the number of independent variables and processes is approaching infinity, and hence reality has to be reduced to a finite number (or, more exactly, a manageable number) of variables and processes which behave as if they were independent. This section will, first, interpret some of the limitations of the theoretical model for purposes of statistical application; secondly, enumerate a number of possible fields of application; and thirdly, investigate the principles of application with reference to these fields.

Limitations in Statistical Application

3.2. First, activities will have to be divided into n groups, called industries, which are to be regarded as homogeneous, and non-primary commodities will have to be divided also into n classes, which are also to be regarded as homogeneous. No distinction can be made in net output according to its uses, that is whether for, say, households or exports, except in the purely accounting sense. All this implies that the model cannot make any automatic allowance for the fact that the composition of a class of commodities may vary according to the industry whose input it is, or that, say, the "quality" or price of exports may be different from that of goods for the home market, though special adjustments could later be made for this factor. Equally, the input structure of an industry cannot adjust itself to changes in the composition of its output, though again special adjustments should be possible; if, for instance, woollen cloths for export contain a higher quality wool than for the home market, different wool input coefficients might be used according to whether export or home demand changes.

3.3. The model cannot work for joint products, that is, it cannot allow for one industry to produce commodities belonging to more than one class. The number of commodity classes

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cannot exceed the number of industries, as otherwise the system would be over-determined; neither can a commodity be produced by more than one industry, since otherwise one of the industries may become superfluous, according to the set of prices used, in which case it would become necessary to introduce further specifications of the equilibrium position.

3.4. Perhaps the most important, certainly the most controversial, limitation is set by the assumption of fixed input coefficients. These fixed coefficients—fixed in relation to a given state of technology—imply not only the homogeneity of industries and of commodity classes, but also that (*a*) there are no increasing or diminishing returns to scale, and (*b*) that there is no substitution of inputs in response to price changes. If one groups activities and commodities, the case of fixed coefficients may be strengthened rather than weakened, since the nearest substitutes fall into the same group. For instance, the substitution of cotton for wool textiles becomes irrelevant if textiles form one group; the substitution of textiles as a whole for labour, on the other hand, can probably be neglected when one considers the clothing industry. This tendency, however, may be offset by substitution due precisely to the heterogeneity of groups; for instance, if the relative price of textiles rises, relative demand for clothing with a high material content is likely to fall, and consequently the input of textiles into the clothing industry may fall relatively to labour. The defence and possible relaxation of this limitation will not be discussed until Section 5.

3.5. The equilibrium condition that the receipts of an industry are equal to its expenditure is a formal one in the sense that profits are included under expenditure and expenditure is restricted to current inputs. There is no difficulty in assuming profits in particular industries to be permanently above or below the "normal" rate of remuneration of capital, but of course the resulting equilibrium must not be regarded as fulfilling the condition of competitive equilibrium. Similarly the equilibrium condition that net output equals output less quantities used as input by other industries is a formal one in so far as stock change may be included in net output, that is, regarded as a final commodity. These limitations mean that the model can be used for problems in comparative statics but not for the solution of dynamic problems; in other words, two equilibrium positions can be compared, but the path by which the new position is reached cannot be traced. There are two main reasons for that: the first is that the input coefficients represent static conditions, that is, they indicate that the production of a commodity *uses up* certain other commodities, but they do not indicate what capital capacity or working stocks are required and what the relationship between input of capital and the *rate of change* of output is; secondly, prices are assumed to be long-term prices which are independent of the rate of capital formation, whereas the price system ought to make some allowance for the finance of investment.

3.6. In a true long-term equilibrium model capital (including stocks) could occur only as an intermediate commodity, but for practical purposes one can consider capital goods and stocks as final output and the use of capital as primary input. In such an application separate attention would have to be paid to the question of adequate production capacity. It might be added that it is not necessary to assume a stationary economy, as the input coefficients can be so defined as to allow for the expansion of the economy at a uniform rate; but the proportionate expansion of all industries at a fixed rate does not yet answer the dynamic problem.

3.7. The main requirement to be fulfilled is that, in relation to the problems considered, final output and primary input should be independent. For instance, the pattern of consumption must be independent of the structure of industry. This, of course, would not strictly speaking be true, as a relative increase in, say, coal mining at the expense of agriculture might increase the consumption of bacon and reduce that of bread in so far as there is a correlation between occupation and the pattern of feeding. More important might be the connection between the aggregate volume of consumption and the supply of labour. These qualifications, however, are likely to be of secondary importance, and an adjustment, if required, should be possible outside the operation of the model.

Fields of Application

3.8. Although the models described may have their most important uses in central economic planning, they are also important for any kind of public policy which influences the structure of industry, and for policies by particular industries repercussions to which may depend on the structure

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of industry. At the one extreme, it must not be assumed that such models of the economy can supply ready-made blueprints for a "dirigist" government, or, on the other, that the usefulness of these models presupposes such governments. Conversely, it is difficult to see how in a modern industrial society comprehensive economic plans can be prepared without close studies of economic interdependence. The danger is that in an emergency planning is introduced piecemeal and therefore inefficiently; in a war economy, for instance, commodities are controlled one at a time, thus putting an additional strain on the supply of substitutes, instead of controls being applied to larger aggregates which, however, are extended to cover the whole economy.

3.9. The foremost field of application is in the preparation of short-term economic plans. Governments are engaged in fixing "targets" for the production or consumption of various commodities ; they allocate materials, influence the distribution of labour and of capital investment. Two kinds of difficulties emerge here: one is that the various targets, plans and actions may be inconsistent, and the other that too little attention is paid to the less important (because less homogeneous) commodities which, however, in the aggregate may have an overbearing importance from the point of view of economic welfare. An example might be the examination of the consistency of production plans of different industries for, say, the next year. Are these plans consistent, in the sense that neither undue strains nor surpluses will arise, and will the pattern of final output emerging be reasonable? In another case one might start from the pattern of final output: suppose that defence production is to be stepped up, what structural changes are required in the economy in order to cover defence requirements, alternatively assuming that consumption or investment will be cut back? One particular application is the finding of "bottleneck" sectors or commodities which are expected to become the limiting factors in production.

3.10. In assessing long-term changes one would start by postulating the pattern of demand, and from that work back to the structure of industry. In the United Kingdom, for instance, in say 5 years' time capital formation might be expected to be on the high side, consumers to spend a higher proportion of their income on durable consumers' goods, and the composition of exports to shift towards capital goods and durable consumers' goods. It would be extremely important to assess the structural consequences of these tendencies: would they, for example, intensify the demand for coal, or the demand for imports? In application to longer-term planning it would of course be less practicable to assume that input coefficients remain constant. It is, however, reasonable to suppose that technological change affects first a few firms in an industry, and then the movement spreads, so that on the whole change is slow and takes the form of making this year's average firm similar to last year's leading firm. Hence models for long-term plans could be based, not on the input coefficients of industry as a whole, but on those of the leading firms only. The comparison between the two sets of input coefficients should be extremely useful for conscious attempts to speed up technological progress, as well as showing the direction in which the structure of industry is likely to move.

3.11. Indeed one of the most interesting uses of the model is to experiment with the substitution of input coefficients based on new inventions for input coefficients as they actually are. For instance, estimates were made of the cost structure of power generated by nuclear fission (Menke, 1947), and this can be substituted in the model for thermal electricity; profound changes would be shown both as regards demand for materials used as sources of energy and as regards the relative cheapening of electricity-intensive commodities, such as aluminium.

3.12. In the field of price-wage policies the model shows the structural relationship between prices and value added. From a set of prices value added by each industry can be deduced, and subsequently, given data on wages, the volume of profits. Alternatively, having determined wages and profits by industry, the resulting prices can be estimated. Thus one can examine the consistency of wage-price-profit controls or, what may become more important, can use the model for purposes of minimizing the number of controls necessary in so far as the model points to the strategic prices to which controls could be confined. The effects of a change in wage rates or profit margins in a particular industry can be worked out in terms of the prices of final commodities, distinguishing primary and secondary changes (Leontief, 1946*b*).

3.13. The model is likely to be indispensable in the case of demand studies for intermediate commodities such as steel. Correlating steel consumption with historical series of national income, of which only a small proportion is spent on steel, will not give satisfactory results, since the structure of the economy and national income are likely to have been historically correlated over

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the trade cycle, and therefore the coefficients obtained from such correlation cannot be used to forecast the consequences of a structural change in the economy which takes place without a change in national income. It is interesting to note, however, that in the United States a high-investment (or defence) economy requires about as much steel as a high-consumption economy, mainly because of the high expenditure-elasticity of motor cars. Any conclusion on the stability or instability of demand for an intermediate commodity in the face of profound structural changes in the economy forms a valuable contribution to market research.

3.14. In countries like the United Kingdom an important use is the examination of repercussions caused by changes in international trade. The dependence of employment on exports can be estimated (Leontief, 1946*a*; Hoffenberg, 1947). Imports required for an increase in exports can be evaluated. Plans for the building up of complementary import-saving industries can be examined. The consequences of a rise in import prices can be traced, or of a rise in wages as it affects exports.

3.15. In the field of general indirect taxes (or subsidies) which are placed on industry—such as duties on petrol for road transport, employers' social insurance contributions, or taxes on business premises—the model can be used to estimate their incidence on final prices. An increase in social insurance contributions, for instance, will bear more heavily on final commodities with a high cumulative labour content.

3.16. An advantage of a more technical nature derived from the application of the model is that it enables a more detailed analysis to be carried out on the success or failure of particular economic plans. As a very simple example, plans for a certain amount of coal to be produced can be reached with a lower manpower (labour input) but a higher productivity (smaller input coefficient) than expected. Lastly, it may be mentioned that the computation of the transaction matrix itself mobilizes a vast amount of economic statistics, places it in an orderly form, throws light on inconsistencies, points out lack of independence, and in general greatly improves the accuracy of the customary form of national income estimates.

3.17. Studies of inter-industry relationships were used, in conjunction with other studies, to illustrate the likely pattern of full employment in the United States (Cornfield *et al.*, 1947); in the preparation of the development plan for Israel (Gruenbaum, 1950); and as an aid to economic planning in general in Denmark (Statistiske Departement, 1951), the Netherlands (Centraal Bureau voor de Statistiek, 1950, 1951; Loeb, 1950), and Norway (Aukrust, 1950).

The Principles of Statistical Application

3.18. The main concern of statistical application is the specification and grouping of commodities and activities, and it should be stated at the outset that the grouping which may be appropriate for the examination of one problem will not necessarily be the best for another.

3.19. An activity consists of the combination of commodities in order to obtain other commodities. Hence the employment of civil servants is not an activity; but civil servants and paper combine to produce government services. The consumption of medicine is not an activity; but the production of medical services, using doctors and medicine as inputs, is an activity. Eating food is not an activity since it produces "satisfaction" and not a commodity distinct from food itself. In the marginal case household operation could be regarded as an activity, with household goods and domestic service (or the service of housewives) appearing as inputs instead of as final goods.

3.20. The specification of commodities follows from that of activities, but difficulty arises over a wide field of activities—distribution—where the result is the production of commodities which have changed their locality or ownership but have undergone no physical change. It would be, for instance, wrong to regard railways as producing potatoes, but rather as producing transport services which are used for some purpose jointly with potatoes. Things commonly called commodities are never homogeneous in the strict theoretical sense, but can be regarded as such for most practical purposes. In some sense the homogeneity of a commodity can never be absolute, since new inventions may discover new uses and hence further differentiation; eggs would cease to be homogeneous if it became possible to tell the sex of the bird to be hatched from them. Technological progress keeps enlarging the number of commodities and thus makes

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classification difficult, although in exceptional cases old commodities cease to be actually used as a result of alternative processes being introduced.

3.21. Because of the lack of homogeneity, for purposes of aggregation adding values is generally preferable to adding weights or other physical attributes. For instance, different kinds of finished steel have widely different prices per ton, corresponding to the amount of crude steel, labour and fuel required in their making, and a better expression of input content is obtained in terms of sterling than in terms of tons. Money values should therefore be regarded as of the nature of index-numbers of physical quantities; in other words, the natural unit of any commodity can be arbitrarily chosen so that the unit price should equal one pound sterling and thereby natural units become additive. A number of problems arising out of quality differences would be by-passed through this method.

3.22. Widening the concept of commodity, it becomes obvious that commodity classes should be formed by substitutes, that is, commodities which are in most respects alike. In the application of this principle, however, a fundamental difficulty is encountered, namely that commodities which are substitutes on the output side may not be substitutes on the input side. For instance, cotton and rayon yarn or textiles are substitutes from the point of view of the consumers of these products, and therefore grounds would exist for aggregating the production of cotton and rayon textiles into a single industry. The raw materials used for cotton yarn, however, have a widely different origin from those used for rayon, and the processes employed are also different, and hence reasons arise for not aggregating cotton and rayon textiles. In fact, this dilemma is hardly avoidable, and a practical choice must be made between aggregation according to output or input similarities. In the cotton-rayon example, if a choice has to be made the two industries would be aggregated, since product substitution has in recent years become very strong; indeed a very large proportion of textiles uses mixtures, the proportion varying according to relative prices. On the other hand, different rolled steel products would be aggregated because substitution on the input side is much more important than substitution between, say, structural steel and timber for building purposes. There can be, of course, nothing final about these decisions and for some purposes they may have to be altered; for instance, in a study of import-saving it would not be helpful to aggregate cotton and rayon textiles.

3.23. Both kinds of aggregation of commodities lead to a similar kind of aggregation for activities, commonly called horizontal integration, and opposed to this is the principle of vertical integration, that is, the combination of activities which are successive in the chain of productive processes. Again, it should be pointed out that no industry, however small, contains entirely homogeneous processes, but within any industry, or even workshop, a set of integrated activities takes place. The assumption is that certain commodities are intermediate from the point of view of the industry or the workshop, and hence do not enter into a picture of transactions with the outside world, but in reality no commodity is necessarily internal for a workshop, at least not potentially, and with possibilities of international trade not even for an entire industry. The example of the wool industry is well known—wool can be bought at a number of different stages of processing (as greasy, as scoured or as combed), and at each stage imports and exports take place, as well as transactions between firms within the industry as commonly defined. If, however, it is found that almost the whole output of an activity is used as input by a single activity, the two can be combined; if cotton yarn is preponderantly used for cotton cloth, cotton spinning and weaving can be combined into a single industry and cotton yarn would disappear from the system as a commodity. In reality difficulty will be encountered, as both yarn and cloth are exported and, for instance, the import content of the two is different.

3.24. The principle of vertical integration is in direct conflict with the principle of horizontal integration in the case when the effects of technological change are investigated. Inventions are likely to affect one process at a time in a chain of successive industrial processes: witness the inventions of the industrial revolution in the textile industry, or the more recent inventions in the mechanization of cotton growing. Consequently, there is a case for grouping parallel processes rather than successive processes; thus, in the field of non-ferrous metals, the smelting of all metals would be one industry and the rolling of all metals another, rather than all processes dealing with copper one, those dealing with zinc another, and so on.

3.25. Throughout the application of these principles, size (in terms of value) must be kept in view. Heterogeneity is easily forgiven if the total value of output of a commodity is small, and

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activities are more readily integrated if the difference between the value of output and dominant input is small (which is the case of processing wool and many other commodities of agricultural origin). As the result of successful grouping, a certain evenness may be shown both by the size of industries (as measured by value of output) and by the size of the input coefficients, except in so far as they indicate precisely the interdependence of the economy. It also follows that grouping will have to be modified as industries decline and expand.

3.26. It should be added, though it is outside the scope of the present paper, that in dynamic models further criteria of classification are introduced. One is the ratio of capital to output, and the other the period of replacement of capital; hence commodities can be classified according to the additional criterion of durability, and activities according to capital intensity.

3.27. In so far as the value of output of an activity is estimated independently from the value of inputs, and the net output of a commodity independently from its output less its use as input by each activity, statistical gaps will arise in the transaction matrix. The actual gaps are, however, not identical with statistical errors in the usual sense, although they incorporate such errors; they arise rather from the fact that the estimates are *incomplete* in so far as there is a category "unallocated" both among the cost items of an industry and in the list of destination of its products, and thus the gap tends to be positive. For accounting purposes it is necessary to distinguish an "unallocated" class of commodities, and also to set up a dummy sector to which specific commodities which remain "unallocated" can be directed. This dummy sector cannot be treated as an industry, since the relationships between its "output" and "inputs" are by no means technological, and hence commodities going into it must be included in net output. If, for instance, water is used by all industries in unknown quantities, it is best to include the whole output of water as "unallocated" in net output. In each case when the pattern of net output is specified, it must then be remembered to include water in some relation to national output, and, if possible, by making some intuitive allowance for changes in the structure of industry. It is evident that a diminution in "unallocated" items by appropriate estimates, no matter what their margin of error provided that they are unbiased estimates, and then working through the equations, is preferable to intuitive adjustments; in practice, however, the cost of additional estimates may be prohibitive.

3.28. Another practical difficulty is that the smallest unit of statistical observation (the "establishment") is not small enough to be confined to one "activity", and hence it may produce more than one commodity; whatever reasonable grouping of activities and commodities one adopts, some industries are likely to produce commodities belonging to more than one class, in the sense that they are the main product of more than one industry. This is a much more important hindrance to the working of the model than joint products proper which, with one or two exceptions, hardly cut across the industrial classification. Since the results will have to be interpreted in terms of administrative categories, no great loss is suffered if, instead of commodity classes which cannot be made to correspond exactly to industries, eventually commodities are classified simply according to the industry of origin, irrespective of their physical nature.

3.29. For the purposes of the model it is superfluous to estimate transactions within an industry, and indeed such transactions cannot be uniquely defined. For the interpretation of results or administrative purposes it is, however, useful to have such transactions recorded, and these can be recorded according to the administrative definition of the unit of observation; it will then be known that out of the total (gross) value of output of all establishments in an industry a given proportion represents intra-industry transactions. In some cases one might even record transactions within the establishment, so that the definition of total transactions becomes independent of the particular form which industrial organization takes; such estimates exist, for instance, for coal, crude steel, cotton yarn and certain chemicals.

4. *Inter-industry Relations in the United Kingdom in 1935*

4.1. It cannot be pretended that the principles announced in the previous section have been fully applied to the analysis of the interdependence of the British economy in 1935, and this is mostly due to an inadequate volume of data. The basic source of data is to be found in the accounts of economic units—businesses, households and governmental agencies—and hence each transaction is in principle recorded twice, at its origin and at its destination; in fact it was seldom found that a given transaction was available from two different sources. An alternative

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method to the accounting approach would be the use of direct data on input coefficients derived from engineering knowledge; a complete matrix of coefficients could be built up with such data, although, in general, data of this nature relate to individual firms rather than to whole industries. A certain limited use was made here of engineering data to supplement the main body of statistics.

4.2. In the following paragraphs a description will be given of the definitions of final output and primary input adopted, of the classification of industries, and of the recording of transactions. To a very large extent the specifications adopted were dictated by the nature of the statistical data, but otherwise, where choice was possible, it was intended to build up a transaction matrix serving for general rather than for certain special purposes; for instance, for a special study of demand for steel one would adopt a rather fine classification of the steel-using industries, but it would be quite safe to lump together large sectors of other industries. The year 1935 was chosen as it was the last year for which a census of production was taken and fully published at the time when the study began.*

Final Output and Primary Input

4.3. In comparison with the abstract model—which referred to a closed economy and static conditions—the actual economy is open and dynamic; in other words, one must recognize international trade and the process of capital formation.

4.4. In so far as international trade is confined to final commodities, no complication will arise except that it becomes more difficult to estimate from demand equations the probable pattern of final output of the economy. Serious complication, however, arises from the fact that trade in intermediate goods also takes place, and consequently the structures of various national economies are themselves interdependent. As it is not possible to extend this analysis to a whole range of countries, it will be assumed that the *pattern* of exports and the *pattern* of imports are independent. The aggregate values of exports and imports are of course not independent, since practical limits are set to the balance of payments, and its value can even be deliberately planned; nevertheless, exports will be regarded as part of final output and imports as part of primary input, and care will have to be taken in the working of the model to take into account the question of the balance of payments. It is realized that, although this procedure is on the whole not objectionable, exceptions can be found where real economic relations are suppressed. It is well known, for instance, that imports of sardines from Portugal or corned beef from the Argentine are technically dependent on exports of British tinplate, and even imports of beef from East Africa require exports of barbed wire for fencing cattle-raising ground. In all these cases exports ought to be not part of final output, but input of an activity supplying goods to Britain. Limiting cases can be found when an activity within the territorial boundaries of a country is structurally interdependent with another country rather than with the country of location. Some Continental smelters of non-ferrous metals import ore and export most of the metal; Middle-East oil companies import almost all their input, except labour, and export almost all their product. In such cases there would be justification for taking the boundaries of the economy differently from territorial boundaries, since an analysis on this basis would be more effective for purposes of policy making.†

4.5. In a dynamic model capital formation plays its full role in so far as there are structural relations between the input of capital to-day and the output of final commodities to-morrow. In a static model no net capital formation takes place and the whole output of capital goods is used to replace existing stock; in other words, the relevant input coefficients represent capital consumption. In the transaction matrix actually evaluated one should have regarded net capital formation as part of final output, and that part of the output of capital goods which corresponds to capital consumption as intermediate commodities. While this method of presentation would be the desirable one, it was not feasible; from the output side, even if it were possible to ascertain the industry of destination of particular capital goods, it would not be possible to distinguish replacement from net investment (and in any case data for several years ought to be averaged), and from the input side, even if it were possible to estimate capital consumption (roughly equi-

* For details on statistical methods see Appendix B.

† This reasoning would justify the particular treatment of oil and insurance in the Treasury's balance of payments estimates.

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valent to depreciation allowances) for individual industries from financial statistics, no satisfactory commodity breakdown would be available at the present, and hence the industrial origin of capital consumption could not be found. Consequently the whole of gross capital formation was regarded as final output, and capital consumption as primary input. An allowance can be made in the working of the model for desired levels of net investment, but the relationship between the *pattern* of capital formation and the *pattern* of capital consumption cannot be taken into account. The definition of capital consumption (and correspondingly of capital formation) can be sufficiently narrowed, however, so that it should exclude, as far as possible, what can be called "maintenance" and remain restricted to "depreciation" proper.

4.6. The qualifications regarding the treatment of capital formation related, strictly speaking, to fixed capital only, that is, commodities which are "durable" and take a long time to be used up in the process of production. As far as "non-durable" commodities are concerned no complication arises, as only net accumulation of stocks is included in final output.

4.7. Final output, on this basis, is thus devoted to consumption, gross capital formation and exports, and primary input consists of services of labour, land and capital, capital consumption and imports. The only justification which may be given is that within limits it should be possible to analyse short-run changes in the structure of industry on the basis of these concepts; the short-run limiting factors are capital capacity and foreign exchange reserves.

4.8. The practical issue to be decided is whether a commodity should be regarded as final or not; put in another way, when is a commodity an input of one of the industries and when is it part of net output? This question is intimately connected with the definition of national income, but little guidance can be derived from that source in deciding on marginal cases. The criterion adopted here was that a commodity was to be regarded as intermediate, that is, required for the production of another commodity, if variations in its output were required corresponding to variations in the *structure* of industry. Final output as a whole is of course required for the supply of primary input as a whole; but the same final output should be adequate for supporting alternative distributions of primary input between industries. With a given consumption of bacon, for instance, manpower may be distributed in a number of different ways; if, however, the bacon consumption of men increases when they are transferred to coal-mining, the national consumption of bacon will vary with the structure of industry and, in that event, bacon (or at any rate the extra amount required by miners) ought to be regarded as an intermediate commodity.

4.9. This approach gives one a useful distinction between business costs (input) on the one hand and consumption (final output) on the other. The argument does not say that miners do not derive satisfaction from eating extra bacon or stockbrokers from wearing a top hat; it simply states that demand for these items is determined by a different set of equations than consumption proper. A rise in income tax, for instance, may induce farmers to consume less of their own produce and sell more, without any direct effect on the process of production, and hence farmers' personal consumption must be kept separate from the input of agriculture; the distinction rests, not on the formal criterion of accounting practice, but on real economic relations. There is nothing absolute about these relations. Normally, food consumed by workers is not an input of industry, but at low standards of living food consumption is directly related to output. Further, these relationships depend not only on technology but also on the given framework of society; a hundred years ago pit-head baths would have been part of final output, but to-day they are an input of coal-mining.

4.10. Particularly difficult decisions have to be reached on the place of certain government services which do not *directly* contribute to welfare, such as general administration, or roads. In so far as such services (for instance, general administration) are necessary for the running of the economy as a whole, but do not particularly depend on the structure or size of industry, it does not help to regard them as input, since they could be imputed to industries only on some metaphysical basis. They are best regarded as part of final output, not necessarily because they contribute to welfare, but because their output is structurally independent of the other economic relationships considered; the same of course may equally apply to haircuts or to surgical operations.

4.11. On the other hand in the case of, for instance, services providing roads, output is, at least partly dependent on the size and structure of industry, and methods might be found for the evaluation of the relevant input coefficients. Such evaluations, however, were not available and could not

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easily be computed, and consequently road services were regarded as part of final output, for the same reason as "unallocated" commodities were so regarded.

4.12. When defining capital formation, it is necessary to refer to durability in relation to the period considered. If the period is long, the concept of capital formation tends to be reduced to net accumulation. In the present case "capital maintenance" is regarded as (current) input and "capital depreciation" as final output; maintenance generally consists of repairs and renewals which take place with a frequency of not more than one or two years, and it was assumed that this definition broadly corresponds to the practice of recording inputs in the census of production. Thus, with small exceptions, final output corresponds to the sum of the official concepts of personal consumption, government consumption, gross capital formation and exports (including "invisibles"), and primary input to the sum of gross national income and imports.

Classification of Industries

4.13. The major classification of activities into industries is with reference to the census of population industrial classification. An important distinction will be made between activities producing physical commodities (agriculture, mining, manufacturing, public utilities and building) and activities producing services. Whilst the former class produces commodities which are derived from other commodities through physical or chemical changes, the latter class *either* takes the commodities produced by the former class and, without subjecting them to physical or chemical change, changes their location (transport) or holds them from one period to another (storage), *or* supplies commodities which are not transferable from one owner to another (personal, professional and governmental services). The activities which transport and store physical commodities—distributive industries in the widest sense—should be taken as resulting, not in the output of physical commodities in a new place or at a new time, but rather in the output of distributive services (transport, storage, communication, commerce, finance, insurance and real estate agencies).

4.14. The distinction between industries producing physical commodities and those producing services cannot be made watertight for two different reasons. First, certain service activities take place within industries producing physical commodities (such as transport or advertising) and, conversely, a certain amount of physical production takes place in the service industries (such as butter production by milk distributors); the census of production, however, attempts to obtain data for small accounting units so as to exclude service activities. But—and this is the second reason—even the smallest economic unit may be engaged in more than one type of activity, and it would be neither practicable nor desirable to separate these. Repairs are a class of activity which is to a large extent included in the output of manufacturing industries. On the other hand, the distributive trades necessarily engage in a certain amount of physical production, such as breaking bulk, sorting, blending, or packaging, and in the extreme case we find, for instance, butchers producing sausages. Thus we are forced to adopt anomalous procedures in marginal cases and regard factory-made sausages as a commodity, but the sausage produced by the local butcher is looked upon as meat: a certain proportion of less desirable ingredients, casing, *plus* distributive services.

4.15. The classification adopted* distinguishes agriculture, forestry and fishing as one category; 33 industries in the sectors covered by the census of production; the distributive industries; and, lastly, other service industries, a total of 36 categories. Although separate computations were made for agriculture, for allotment and backyard farming, for forestry and for fishing, it was not possible to break down the largest component, agriculture itself. Agriculture, as has been often said, is composed of more than one industry; but the departmental statistics which have been used here did not permit a distinction to be made between crop-growing, livestock farming (with the possible separation of dairy farming) and horticulture, however desirable that would have been in order to obtain a more balanced classification. The area of the census of production was dealt with in most detail, partly because of the relative abundance of data, and partly because it is in this area that inter-industry relations are the strongest and most important. Separate computations were made in respect of all the trades distinguished in the census of production, some 140 (including a number of government industrial departments), but no entirely

* For details see Appendix A.

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satisfactory classification was possible along the lines indicated in the previous section. To a large extent the census of production was based on the historic development of industry: thus mechanical engineering formed a huge trade (with insufficient detail published for individual sections of it), compared with which the incandescent mantle trade looked insignificant; the important motor industry was lumped together with bicycles, probably because it was a cycle maker and not a coach builder who developed the industry; and rayon was not distinguishable from silk, probably because a silk thrower instead of a chemist founded the industry. In general, not enough attention was paid in the census to the size and structure of different industries, but some of these defects have been eliminated since. Even if the refinements of the previous section may not look immediately relevant, they might help in the introduction of the principle of design of experiment in the collection of industrial statistics.

4.16. It would also have been desirable to divide service industries into more than two categories, but the poverty of data in this field is so great that no reliable separate estimates were possible for important sectors, like road transport. In order to follow conventional national income practice, the management of dwellings was regarded as an activity producing services (equivalent to gross rents), and having as its input items connected with the maintenance of dwellings but not, of course, new construction; dwellings are regarded as capital goods (whether let or owner-occupied), in contrast to motor cars and other durable goods in personal ownership the output of which is simply entered into consumption. For similar reasons the management of foreign investment is also regarded as an industry with profits and interest from abroad as its output and certain headquarters expenses as input. The two last mentioned "industries" are part of the class "other services."

4.17. Household operation by housewives, unlike that by paid domestic servants, was not distinguished as an activity, however valuable its results may be. The census of population does not of course regard housewives as such as occupied persons, but this would not have been sufficient reason for adopting a similar procedure here. The fact is, however, that household operation by housewives is not an activity in the strict sense because its input coefficients are only vaguely determined by technical relations. The amount of household machinery employed, for instance, depends on factors similar to those determining the consumption of food rather than those determining the employment of machinery in industries within the market system. Further, in normal times housewives are not transferable from household operation to other activity, and hence they had better be disregarded when considering, say, the allocation of man-power; this of course is not the case in, for instance, a war economy, when one might consider household operation as an "industry". For somewhat similar reasons, work done for oneself (such as painting one's own house) is not regarded as an activity.

Recording of Transactions

4.18. In general, transactions are recorded on the same basis as in the census of production, that is, taking into account current production valued as it leaves the hands of employees of the establishment for which records are kept. In certain cases—publishers and speculative builders, for instance—value added outside the records of the census of production has been included; production parallel to that in the census—such as watch assembly by repair shops, or butter production by milk distributors—was also included; work on commission basis (mainly textiles and clothing) was revalued so as to include the full costs of production and not only payment for work done, and certain commission work separately recorded (e.g., textile finishing) was added where appropriate.

4.19. Some difficulty is always experienced in recording movements of waste and scrap materials and of second-hand goods. The output and input of waste materials is normally recorded, except that scrap metal, other than process and circulating scrap, is *deducted* from capital formation (negative entry). Transactions in second-hand goods do not enter the picture unless such goods are repaired or reconditioned, but international trade in second-hand goods is normally recorded with offsetting entries elsewhere; thus if second-hand cars are exported, the output of cars for domestic consumption is correspondingly reduced.

4.20. Imports are recorded c.i.f., although it would be preferable to record them f.o.b. and take transport and insurance costs separately, but no alternative calculations by commodity

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were available. Consequently, the *whole* output of United Kingdom shipping was entered into exports. Movements in precious metals were recorded only in so far as refining took place in the United Kingdom and other movements were regarded as on capital account.

4.21. A problem arises in connection with the output of the distributive industries, that is, the gross distributive margin, which is measured as the difference between input value at one stage (or value of final output) and output (or c.i.f. import) value at the previous stage. The assumption that the physical commodities distributed would be regarded as the input and the output of the distributive trades has been rejected, partly because, having lumped the distributive trades into one category, all commodities would then appear as part of the homogeneous output of the distributive industries and thereby lose their identity on passing through distribution. Even so, two alternatives remain: the output of the distributive industries can be taken as the input either of the producer or of the consumer of the physical product which is distributed and, clearly, the choice must not depend on the financial relationships observed. It was decided to regard distributive services as the input of the consumer, that is, as if it were the joint product of the physical commodity which is being distributed, mainly because distributive margins vary with classes of consumers (being particularly high at the retail stage), and this distinction would otherwise be lost. Thus the input of, say, building consists of building materials as valued in the census of production *and* transport and other distributive services not included in that valuation.

4.22. All transactions are recorded in market prices and, consequently, the value of primary input includes indirect taxes or is offset by subsidies. The valuation of transactions at "factor cost" would be impossible, since one cannot trace the incidence of some indirect taxes except precisely through the equations derived from the tables that will follow.

4.23. Within-industry transactions were also recorded, and for the census of production industries they represent transactions between establishments in the same category. The output of agriculture is, however, recorded on a "national farm" basis—that is, exclusive of inter-farm transactions—and the small figure shown in Table 7 below represents the input of backyard farming from agriculture proper (such as store animals). Transactions within the distributive industries represent freight transport included in gross distributive margins, and those within other service industries certain professional services for industries within the sector.

Comments on the Results

4.24. Table 5 shows the output of agriculture, etc., mining, manufacturing, building and public utilities in terms of commodities. Parallel imports and customs duties on those imports are also given so that the total supply of each commodity-class can be shown. A commodity-class was defined as consisting of the "principal products" of an industry as defined in the census of production, with minor adjustments. It was found, however, that output worth £14 mn. consisted of scrap and waste materials and another £5 mn. of unspecified commodities which the census did not regard as the "principal product" of any industry. Relatively little output consisted of products characteristic of industries other than the industry in which it was actually produced, since only 33 groups were distinguished in the area of the census of production; most of such "other output" was in fact the characteristic output of neighbouring groups. In spite of the fact that departments attached to mining and manufacturing industry producing electricity or engaged in building activity should have been recorded as part of the electricity or building industry, a certain amount of electricity and building work was recorded as being *sold* from one establishment (in mining or manufacturing) to another; generation of electricity for own purposes was regarded as part of the activity to which it was attached and, in so far as mining or manufacturing establishments used their own labour for construction, such building work escaped registration except as purchases of materials and payments of wages.*

4.25. Table 6 shows the input of the same 34 industries in so far as it consists of commodities the supply of which was shown in the previous table. In addition distributive margins and excise taxes (or subsidies) are also given. The total inputs shown in the table correspond to the input concept of the census of production. Tables 5 and 6 amalgamated (with appropriate positive

* The construction departments of public utilities, etc., are, however, included in the building industry.

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TABLE

The Supply of Com

From / *Commodity Class*		Industries 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Agriculture, etc.	1	293·8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Coal mining	2	..	145·2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Other mining	3	..	0·4	21·3	0·7	0·4	..	..	..	..	..	..	..	..	..	..	..	..
Building materials, etc.	4	..	..	0·1	60·6	0·5	0·1	0·2	..	0·5	0·2	..	..	..	..	..	..	..
China, glass, etc.	5	..	..	..	0·4	30·6	..	0·2	..	..	..	..	..	..	..	..	..	..
Coke	6	..	..	..	..	..	11·9	1·8	..	0·1	..	..	..	..	..	..	..	..
Chemicals, etc.	7	..	..	0·1	0·1	..	1·5	86·0	0·9	0·6	..	0·6	..	0·4	..	..	..	..
Soap, polishes, etc.	8	..	..	..	..	..	..	2·1	37·6	0·3	..	..	..	..	..	..	..	..
Oils and paint	9	..	..	..	..	..	2·6	2·0	0·6	78·1	..	0·1	..	..	..	..	..	..
Iron and steel	10	..	..	..	..	..	..	..	..	..	183·2	0·5	..	3·3	0·4	..	..	1·7
Non-ferrous metals	11	..	..	..	..	..	..	..	..	..	0·5	51·0	..	..	..	0·1	..	..
Shipbuilding	12	..	..	..	..	..	..	..	..	..	..	..	46·2	..	..	..	..	..
Mechanical engineering	13	..	..	..	..	0·2	..	..	..	..	1·8	0·5	0·1	173·4	3·0	2·2	0·1	0·1
Electrical engineering	14	..	..	..	..	..	..	..	..	..	0·1	..	..	0·8	102·6	0·3	..	..
Motor and cycle	15	..	..	..	..	..	..	..	..	..	..	..	..	1·3	0·2	165·5	..	0·8
Aircraft	16	..	..	..	..	..	..	..	..	..	..	..	..	0·1	..	0·4	14·3	..
Railway rolling stock	17	..	..	..	..	..	..	..	..	..	..	..	..	0·2	0·1	0·5	..	42·1
Metal goods, n.e.s.	18	..	..	..	..	..	..	0·1	..	..	1·9	2·8	..	6·2	2·2	1·6	..	..
Cotton and silk	19	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Woollen and worsted	20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hosiery and lace	21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Other textiles	22	..	..	..	..	..	..	..	..	..	..	..	..	0·1	..	..	..	..
Textile finishing and packing	23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Leather and fur	24	..	..	..	..	..	..	0·1	..	..	..	..	..	..	..	..	..	..
Clothing	25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Food processing	26	..	..	..	..	..	..	0·5	..	1·9	..	..	..	..	..	..	..	..
Drink and tobacco	27	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Manufactures of wood	28	..	..	..	0·1	..	..	..	..	..	..	..	..	0·1	..	..	..	..
Paper	29	..	..	..	..	..	..	0·1	..	0·1	..	..	..	..	..	..	..	..
Printing and publishing	30	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubber	31	..	..	..	..	..	..	0·1	..	..	..	..	..	..	0·1	0·1	..	..
Miscellaneous manufacturing	32	..	..	..	0·1	..	..	..	..	..	..	..	..	..	..	..	..	..
Building and construction	33	..	..	0·4	0·1	0·7	..	..	..	..	0·3	..	..	..	..	..	..	..
Gas, electricity and water	34	..	0·9	..	0·1	..	1·2	..	0·1	..	1·6	..	..	..	..	0·3	..	..
Commodities not elsewhere specified:																		
Scrap and waste		..	..	..	..	..	..	..	..	0·2	3·2	1·2	..	0·7	0·5	0·1	..	0·2
Unspecified goods		..	..	..	..	..	..	..	..	..	0·4	0·5	0·2	0·3	0·5	0·4	..	..
Total value of output		293·8	146·5	21·9	62·2	32·4	17·3	93·2	39·2	81·8	193·2	57·2	46·5	186·9	109·6	171·5	14·4	44·9

and negative signs) would give input-output coefficients proper for 34 industries and 34 commodity classes.

4.26. Table 7 contains the final matrix of transactions and, in contrast to Table 6, it records input not according to commodity class but according to producing industry, distinguishing imports as one category. The computations had to make certain arbitrary assumptions, as in most cases it is not possible to derive from the specification of the commodity its origin, but it must be remembered that the computations were done with reference to individual commodities and not classes; proper estimates were possible only in isolated cases as, for instance, home-produced malting barley was distinguished from imported barley. It was assumed that when an industry both bought and sold, say, electricity, sales went to establishments in the same industry; also, it is safe to think, for instance, that barrels produced by breweries (as "other output") were used by them. Further, the table was extended so as to include the two categories of service industries; it should be noticed that the difference between inputs of services shown in Table 7 and the distributive margins shown in Table 6 consists of services, such as advertising or postal services, which the census of production includes in "net output". Indirect taxes include customs duties, which in Table 6 were embodied in the value of commodities.

4.27. A word needs to be added on that part of the final output which consists of "primary commodities", and which is recorded for the sake of completeness and also for obtaining the balance

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5

modities. U.K., 1935

£ *million*

Industries																	*Tota. Domestic Output*	*Im-ports*	*Duty*	*Total Supply*
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34				
..	..	..	..	..	..	0·1	..	..	..	..	..	..	..	..	..	..	293·9	337·1	90·0	721·0
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	145·2	..	..	145·2
..	..	..	..	..	..	..	..	0·4	..	..	..	..	..	..	..	..	23·2	18·9	0·2	42·3
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·5	..	62·7	2·4	0·3	65·4
0·1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	31·3	4·6	1·0	36·9
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10·9	24·7	0·1	..	24·8
0·6	..	..	..	..	..	0·1	..	0·4	..	..	..	..	0·2	0·1	..	1·3	92·9	16·3	1·5	110·7
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	40·0	2·7	2·2	44·9
..	..	..	..	..	..	..	..	1·0	..	..	..	..	..	..	..	0·7	85·1	47·6	45·4	178·1
6·2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	195·3	7·2	1·5	204·0
2·1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	53·7	27·1	0·5	81·3
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·4	..	46·6	2·6	..	49·2
1·5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	..	183·0	12·8	1·7	197·5
0·5	..	..	..	..	..	..	..	..	..	..	..	..	0·1	..	..	..	104·4	3·7	0·7	108·8
0·9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	168·7	4·1	1·4	174·2
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14·8	0·1	..	14·9
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	42·9	..	..	42·9
158·5	..	..	..	0·2	..	..	..	..	..	0·9	..	..	..	0·4	..	..	174·8	39·8	2·3	216·9
..	206·4	1·4	0·2	1·9	0·3	..	0·9	..	..	0·3	..	..	..	..	..	..	211·4	9·0	.. 2·8	223·2
..	0·5	140·0	0·2	0·1	..	..	0·1	..	..	..	..	..	..	..	..	..	140·9	2·7	0·3	143·9
..	3·6	..	46·9	..	..	..	..	..	..	..	..	..	..	..	..	..	50·5	2·2	0·7	53·4
..	0·3	..	..	57·9	..	..	0·1	..	..	0·1	..	..	..	..	..	..	58·5	4·6	0·2	63·3
..	0·1	0·1	0·5	..	31·7	..	..	..	..	..	..	..	..	..	..	..	32·4	..	..	32·4
..	..	..	..	..	..	46·1	0·1	..	..	..	..	..	..	..	..	..	46·3	10·7	0·7	57·7
..	0·3	..	0·3	0·3	..	0·1	220·6	..	..	..	..	..	0·9	..	..	..	222·5	6·5	1·5	230·
..	..	..	..	..	..	..	..	403·3	0·2	..	..	..	..	..	..	..	405·9	143·0	18·1	567·0
..	..	..	..	..	..	..	..	0·6	360·0	..	..	..	..	..	..	..	360·6	13·8	14·6	389·0
0·5	..	0·1	..	0·2	..	..	0·2	0·1	0·5	95·3	0·1	..	..	0·1	1·6	..	98·9	42·7	3·4	145·0
0·1	..	..	..	..	..	..	..	0·1	..	..	73·1	5·1	..	..	..	..	78·6	14·1	1·7	94·4
0·1	..	..	..	..	..	..	..	..	..	..	1·2	140·2	..	..	..	..	141·5	1·1	..	142·6
0·1	..	..	..	..	..	0·1	0·4	..	..	..	..	..	26·4	..	..	..	27·3	1·6	0·1	29·0
0·3	0·1	..	..	..	..	0·2	..	..	..	0·2	0·1	..	0·8	23·5	..	..	25·3	2·6	0·5	28·4
..	..	..	..	..	..	..	..	..	..	1·7	..	..	..	..	467·8	..	471·0	..	..	471·
..	..	..	..	..	..	..	..	0·1	..	..	..	..	..	..	0·1	229·4	233·8	..	..	233·8
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1·5	..	..	0·1	..	..	0·3	..	..	..	..	..	0·3	..	..	..	0·2	8·5	5·5	0·1	14·1
0·4	0·1	0·6	0·2	0·5	0·1	0·1	..	..	0·1	0·1	0·3	0·1	..	0·1	0·1	..	5·1	..	..	5·1
173·4	211·4	142·2	48·4	61·1	32·1	47·1	222·4	406·0	360·8	98·6	74·8	145·7	28·4	24·2	470·6	242·5	4,402·2	787·2	193·4	5,382·8

between imports and exports in the aggregate, and other usual components of national income estimates. Imports going to exports are re-exports less the distributive margin. Unallocated commodities entered for personal consumption are a *deduction* due to that part of exports through parcel post which is attributed to persons, and there is also a deduction from capital formation corresponding to capital scrap. Depreciation excludes the maintenance of dwellings, etc., and public property, but includes the equivalent of fire damage to property. Indirect taxes on personal consumption consist mainly of customs duties on imports entering personal consumption directly, duties on private cars, and fees paid to local authorities, mainly for education; rates on dwellings, wireless licences, entertainment duty, etc., were entered as costs of the relevant industries. As a certain proportion of general indirect taxes could not be allocated to particular sectors, a corresponding deduction (£18 mn.) was made from incomes which otherwise would have been over-estimated. The balance of payments can be obtained from Table 3 as exports (the total of column 40) less imports (the total of row 40) and comes to £6 mn. The difference between column and row totals for "unallocated" (no. 41) represents the net accumulation of stocks and the residual error, and its size (£55 mn.) suggests that the total residual error has been reduced to negligible quantities, although this does not necessarily apply to error in each of the components.*

* For more exact definitions of national income components see Appendix C.

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TABLE 6

The Distribution of Co

Commodity Class \ *To:*		*Industries* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Agriculture, etc.	1	11·3	..	..	0·2	..	..	0·9	0·8	14·9	..	..	..	..	0·1	..	..	..	0·5	39·1
Coal mining	2	0·4	4·3	0·8	3·5	1·3	9·4	1·7	0·3	0·4	5·2	0·4	0·1	0·6	0·3	0·2	..	0·4	0·5	1·7
Other mining	3	0·2	..	..	6·4	1·9	..	2·5	..	0·6	8·2	8·5	..	..	0·4	..	..	..	0·9	..
Building materials, etc.	4	0·2	..	..	2·7	0·3	0·3	0·2	..	..	1·4	0·3	..	1·0	0·6	0·1	..	..	0·2	..
China, glass, etc.	5	0·2	..	..	0·1	2·2	..	0·9	0·2	0·3	0·4	0·3	..	..	1·5	1·3	0·1	0·1	0·3	..
Coke ovens	6	..	..	0·1	1·0	0·1	..	2·1	..	0·1	6·7	0·1	0·2	0·5	0·1	0·1	..	0·1	0·3	..
Chemicals, etc.	7	6·1	1·9	0·5	0·2	1·8	0·1	14·1	2·9	3·1	1·1	0·5	0·4	1·7	1·2	0·5	0·1	0·1	2·3	2·2
Soap, polishes, etc.	8	..	..	..	..	..	..	0·2	0·6	..	..	..	..	..	..	..	..	..	..	0·1
Oils and paint	9	12·7	..	0·1	0·2	0·5	..	1·0	6·4	22·9	1·0	0·1	1·3	0·8	0·6	3·4	0·1	1·1	1·3	..
Iron and steel manufactures	10	..	1·3	..	..	..	..	0·8	..	..	52·5	0·6	3·9	30·5	4·0	15·1	0·6	4·9	23·5	0·1
Non-ferrous metals	11	..	..	..	..	0·1	..	1·9	0·5	0·5	5·0	16·5	0·8	4·4	9·0	3·9	1·1	1·5	10·5	..
Shipbuilding	12	..	..	..	..	..	..	..	..	..	..	..	0·3	..	..	..	..	..	..	..
Mechanical engineering	13	1·6	0·2	..	0·4	..	..	0·1	..	..	0·4	..	8·6	14·8	1·0	2·7	0·3	2·7	0·1	2·2
Electrical engineering	14	..	..	..	..	..	..	..	..	..	..	..	1·9	5·0	11·9	2·0	0·2	0·1	..	..
Motor and cycle	15	3·0	..	..	..	..	..	..	..	..	..	..	..	..	..	39·0	..	1·1	..	..
Aircraft	16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1·2	..	..	..
Railway rolling stock	17	..	2·3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·3	..	..
Metal goods, n.e.s.	18	1·8	0·3	..	0·2	0·2	0·1	2·1	0·7	2·3	0·8	0·1	1·1	7·2	6·6	4·3	0·3	1·5	41·9	..
Cotton and silk textiles	19	0·1	..	..	0·3	..	..	0·1	..	0·1	..	..	0·2	0·2	0·9	0·5	0·1	..	..	65·6
Woollen and worsted textiles	20	..	..	..	..	..	..	..	..	..	..	..	..	0·5	..	0·5	..	0·8	..	0·3
Hosiery and lace	21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Other textiles	22	2·4	0·1	..	..	..	..	0·5	..	0·3	0·1	..	0·2	0·4	0·2	1·0	0·2	0·5	..	0·1
Textile finishing and packing	23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22·9
Leather and fur	24	0·1	..	..	..	..	..	..	..	..	..	..	..	0·5	..	1·5	0·1	..	..	0·4
Clothing	25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Food processing	26	48·5	..	..	..	..	..	0·2	..	0·2	..	..	..	..	..	..	..	..	..	..
Drink and tobacco	27	0·7	..	..	..	..	..	1·2	0·1	0·3	..	..	..	..	..	..	..	..	..	..
Manufacturing of wood	28	2·3	5·5	0·6	0·1	0·3	..	0·6	1·0	0·2	0·7	0·1	1·8	2·2	1·6	0·9	0·1	2·1	2·1	0·3
Paper	29	..	..	..	0·3	0·6	..	2·0	1·7	0·1	..	..	..	0·1	0·9	0·2	..	0·1	1·0	1·4
Printing and publishing	30	..	..	..	0·1	..	..	4·6	3·7	1·0	0·3	..	..	..	1·5	1·8	..	..	1·0	0·1
Rubber	31	0·6	..	..	..	..	..	..	..	..	..	..	..	0·7	0·8	6·4	0·1	..	0·3	0·3
Miscellaneous manufacturing	32	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·2	..	..	0·1	..
Building, etc.	33	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gas, electricity and water	34	..	2·2	0·5	1·3	1·2	0·2	1·3	0·1	0·4	3·7	0·6	0·4	2·1	1·3	1·6	0·1	0·5	2·2	1·3
Commodities, n.e.s.		0·1	..	..	0·3	..	..	0·8	..	..	10·2	4·9	..	..	..	..	..	..	0·3	..
Distributive margin		31·3	1·0	0·6	3·6	1·4	1·2	5·6	2·0	4·6	11·5	4·3	1·6	6·3	4·1	5·8	0·4	1·8	4·6	4·4
Taxes*		−10·4	..	..	..	..	..	0·8	2·2	..	..	..	..	..	..	..	..	..	..	2·0
Unallocated		2·1	6·0	1·9	2·5	..	1·7	2·3	..	1·9	11·3	2·2	0·6	0·6	3·3	5·0	0·6	..	6·1	4·0
Total value of purchases		115·3	25·1	5·1	23·4	11·9	13·0	48·5	23·2	54·2	120·5	39·5	23·4	80·1	51·9	98·0	5·7	19·7	100·0	148·5

* Excise duties and wheat quota payments *less* Exchequer subsidies, but not other taxes and subsidies.

"*Unallocated*" *Row and Column*

4.28. The external signs of success of the computation are shown by the row for unallocated goods and services, which is of the nature of residue between the total input of goods and services and its components, but it must be pointed out that total input and its components were not entirely independently estimated. £132 mn. remains unallocated, and of this £10 mn. is attributed to final output. The latter consists of unspecified commodities for government consumption and exports, and the unspecified output of industry, partly offset by scrap and waste products which are not part of the output of industry. £122 mn. is the unallocated input of industry, £2 mn. for agriculture, etc., £90 mn. for the whole range of the census-of-production industries, and £30 mn. for service industries.

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6

Commodities. U.K., 1935

£ million

Industries															*Other Industries*	*Personal Consumption*	*Government*	*Gross Fixed Capital Formation*	*Exports*	*Unallocated, Stocks, etc.*	*Total*
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34							
28·0	..	9·5	..	12·1	1·2	93·3	95·9	1·8	10·8	..	4·7	1·0	..	..	3·3	346·4	4·4	..	39·9	0·9	721·0
1·0	0·1	0·4	1·3	0·2	0·1	1·7	0·8	0·1	1·6	0·1	0·2	0·2	0·4	20·9	20·2	35·0	3·0	..	27·7	−1·3	145·2
..	..	0·5	..	..	..	0·1	..	..	0·5	..	0·1	..	7·3	0·1	..	0·7	..	..	2·0	1·4	42·3
..	..	..	..	..	..	..	..	0·2	..	..	..	..	41·2	1·3	..	2·4	..	3·5	2·5	7·0	65·4
..	..	..	..	..	..	1·8	1·9	0·1	..	..	..	..	7·7	0·1	1·6	10·0	0·2	0·6	4·2	0·8	36·9
..	..	..	..	..	0·1	0·6	0·1	..	..	0·1	..	..	1·3	0·2	2·9	3·5	1·2	..	3·7	−0·4	24·8
0·1	0·1	0·3	5.0	2·3	1·1	2·5	1·5	0·5	1·4	0·1	2·3	0·6	1·4	0·2	0·7	25·0	5·0	..	20·5	−0·7	110·7
0·2	..	..	0·4	0·4	0·3	1·2	..	..	0·3	..	..	..	..	..	1·2	33·8	0·2	..	4·0	2·0	44·9
..	..	0·1	..	0·4	0·3	7·3	0·1	1·0	0·4	2·3	0·1	1·2	7·4	0·7	5·2	33·8	2·3	..	12·0	50·0	178·1
..	..	0·1	..	..	..	0·5	..	0·1	..	..	0·3	0·6	22·6	4·4	..	4·0	0·1	..	25·6	7·9	204·0
..	..	..	..	..	..	0·9	0·2	..	..	0·6	..	0·1	6·3	0·1	..	0·4	..	..	15·9	1·1	81·3
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7·0	0·2	15·9	15·2	10·6	..	49·2
1·4	0·1	0·2	0·3	..	..	0.2	0·1	..	0·3	0·6	..	..	11·5	3·6	..	2·4	12·8	83·5	36·4	9·0	197·5
..	..	..	..	..	..	..	..	..	..	..	..	..	6·4	9·8	..	24·0	0·7	27·9	13·0	5·9	108·8
..	..	..	..	..	..	..	..	..	..	..	..	0·1	0·3	..	9·4	56·0	2·0	39·0	15·3	9·0	174·2
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	8·7	2·3	2·6	..	14·9
..	..	..	..	..	..	..	..	..	..	..	..	..	1·2	..	12·3	..	..	25·6	1·2	..	42·9
..	0·3	0·1	..	0·5	1·9	4·3	0·9	4·9	0·2	0·1	0·2	0·8	14·6	0·4	..	41·0	1·8	1·7	45·7	26·0	216·9
3·2	9·9	3·1	..	0·4	35·2	0·1	..	2·0	0·1	0·5	3·4	0·9	..	..	5·0	28·1	0·1	..	61·3	1·8	223·2
42·6	8·2	1·0	..	0·1	27·1	..	..	2·5	..	..	..	0·3	..	..	4·0	23·0	..	..	33·0	..	143·9
..	4·3	..	..	..	3·4	..	..	..	..	..	..	..	..	..	0·2	40·6	..	..	4·9	..	53·4
2·7	..	15·6	0·1	..	3·2	1·0	..	2·2	1·1	..	..	0·9	1·0	..	4·0	6·6	0·2	..	15·2	3·5	63·3
4·9	2·5	1·6	0·5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	32·4
2·5	..	..	..	12·6	18·6	..	..	0·6	..	0·1	..	0·1	..	..	0·8	12·3	0·1	..	6·4	0·9	57·7
..	..	0·1	..	..	13·6	..	..	..	..	..	..	..	..	..	0·6	204·9	1·2	..	8·2	2·0	230·5
..	..	..	..	..	..	103·9	3·3	..	..	..	..	..	0·2	..	0·8	390·2	3·5	..	16·1	0·1	567·0
..	..	..	..	..	..	1·1	55·0	..	..	..	..	..	..	..	0·3	310·8	..	..	11·2	8·3	389·0
..	..	0·1	0·2	..	0·6	2·3	2·6	27·5	0·1	..	..	1·2	26·1	0·3	1·5	43·3	2·0	2·0	1·6	11·1	145·0
0·4	0·8	0·1	0·5	0·3	1·7	6·7	3·9	0·4	15·1	23·3	0·1	0·3	1·7	..	5·5	10·2	1·2	..	6·5	7·3	94·4
0·1	0·2	0·3	..	..	1·4	4·2	3·6	0·4	0·2	7·0	0·3	0·2	..	0·9	41·0	47·0	4·3	..	4·5	12·9	142·6
0·2	..	0·3	..	..	2·1	..	..	..	..	..	0·3	0·2	0·2	..	..	9·3	0·1	..	4·7	2·4	29·0
..	..	..	..	0·2	..	..	..	0·1	..	0·1	..	0·5	0·6	0·2	1·8	18·8	0·2	..	4·3	1·3	28·4
..	..	..	..	..	..	..	..	..	..	..	..	..	22·2	..	126·1	0·1	54·3	268·0	..	0·3	471·0
0·5	0·3	0·4	0·4	0·2	1·0	8·5	0·8	0·7	0·6	0·9	0·5	0·1	0·6	35·4	15·4	89·9	10·5	34·7	..	11·4	233·8
..	..	2·9	..	0·1	..	0·1	..	0·4	0·7	..	0·2	0·4	..	..	..	−2·7	1·3	−7·7	14·0	−7·1	19·2
4·7	1·3	2·7	1·3	1·6	6·8	20·9	8·0	4·5	3·5	3·4	0·9	1·2	15·9	9·1	9·9	838·6	12·1	16·2	43·0	68·2	1,169·9
..	..	..	..	..	..	6·9	85·6	..	..	0·1	..	..	..	..	10·4	1·5	..	..	..	..	99·1
3·2	0·1	1·8	2·7	1·0	2·2	10·6	..	2·3	2·9	0·6	0·6	1·0	0·2	..	..	..	..	..	..	..	81·3
95·7	28·2	41·2	12·7	32·4	121·9	280·7	264·3	52·3	39·8	39·9	14·2	11·9	198·3	87·7	291·1	2,691·2	149·4	512·5	517·7	243·0	6,733·1

4.29. Expressed as percentage of the output of each industry, on the average only 1 per cent. remains unallocated with the following frequency distribution:

Percentage of Output Unallocated	*Number of Industries*	*Amount Unallocated (£ mn.)*
0–2	19	48·8
3–5	10	40·9
6–8	4	12·6
9–10	3	20·1
Total . .	36	122·4

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TABLE 7

Inter-Industry Rela

To: / From:		Industries																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Agriculture, forestry, etc.	1	1·3	..	..	0·2	..	..	..	..	2·3	..	..	..	..	..	..	..	..	..	..	1·3	..
Coal mining	2	0·4	5·2	0·8	3·6	1·3	9·4	1·7	0·3	0·4	5·3	0·4	0·1	0·6	0·3	0·2	..	0·4	0·5	1·7	1·0	0·
Other mining	3	0·2	..	..	4·9	1·5	..	1·0	..	0·5	2·9	0·8	..	..	0·1	..	..	..	0·1	..	..	..
Building materials	4	0·2	..	..	2·8	0·4	0·3	0·4	..	..	1·4	0·4	..	1·0	0·6	0·1	..	..	0·2	..	..	..
China, glass	5	0·2	..	..	0·2	1·2	..	0·9	0·2	0·3	0·5	0·3	..	..	1·2	1·3	0·1	0·1	0·3	..	..	..
Coke ovens	6	0·8	..	0·1	0·1	0·1	..	1·2	..	0·1	7·9	0·1	0·1	0·5	0·1	0·1	..	0·1	0·3	..	..	..
Chemicals, etc.	7	4·3	1·9	0·5	0·8	1·5	0·1	6·5	1·4	2·2	1·0	0·5	0·5	1·7	1·0	0·5	0·1	0·1	1·9	2·0	0·1	0·
Soap, polishes	8	..	..	..	..	..	..	0·3	1·6	0·1	..	..	..	..	..	..	..	..	..	0·1	0·2	..
Oils, paints	9	10·3	..	..	0·1	0·3	..	1·2	4·4	6·3	0·8	..	1·3	0·6	0·5	3·2	0·1	1·1	1·0	..	..	..
Iron and steel manufactures	10	0·1	1·2	..	0·3	..	..	0·8	..	..	52·2	0·8	3·7	23·3	3·6	13·4	0·5	3·1	22·0	0·1	..	..
Non-ferrous metals	11	..	..	..	..	0·2	..	0·9	0·4	0·4	4·0	5·8	0·7	3·1	5·9	2·8	0·9	1·2	8·4	..	..	..
Shipbuilding	12	..	..	..	..	..	..	..	..	..	..	..	0·2	..	..	..	..	..	..	..	..	..
Mechanical engineering	13	1·5	0·2	..	0·4	..	..	0·1	..	..	0·9	0·2	8·7	16·4	1·4	3·7	0·3	3·1	0·5	2·2	1·4	0·
Electrical engineering	14	..	..	..	..	..	..	..	..	..	0·1	0·4	1·9	5·1	13·0	1·8	0·2	0·2	0·1	..	..	..
Motor and cycle	15	3·2	..	..	..	..	..	..	..	..	..	0·1	..	0·3	0·1	36·2	..	1·1	0·1	..	..	..
Aircraft	16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1·1	..	..	..	..	..
Railway rolling stock	17	..	2·3	..	..	..	..	..	..	..	..	0·2	..	..	..	0·4	..	1·3	..	..	..	..
Metal goods, n.e.s.	18	1·7	0·4	..	0·2	0·2	0·1	2·1	0·7	2·3	1·5	0·8	1·1	9·0	4·5	5·4	0·4	1·6	11·0	..	..	0·
Cotton and silk	19	0·1	..	..	0·3	..	..	0·1	..	0·1	..	..	0·2	0·2	0·9	0·6	0·1	..	..	63·7	3·2	12·
Woollen and worsted	20	..	..	..	..	..	..	..	..	..	..	..	..	0·5	..	0·5	..	0·8	..	0·3	42·1	8·
Hosiery and lace	21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	..	2·
Other textiles	22	2·2	0·1	..	..	..	..	0·5	..	0·3	0·1	..	0·2	0·3	0·2	0·9	0·2	0·5	..	0·1	2·4	
Textile finishing, etc.	23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	23·1	4·8	2·0
Leather and fur	24	0·1	..	..	..	..	..	0·1	..	..	..	..	..	0·5	..	1·5	0·1	..	..	0·4	2·5	..
Clothing	25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Food processing	26	41·6	..	..	..	..	..	0·2	..	0·2	..	..	..	..	..	..	..	..	..	..	..	..
Drink and tobacco	27	0·7	..	..	..	..	..	1·2	0·1	0·3	..	..	..	..	..	..	..	..	..	..	..	..
Manufactures of wood	28	1·7	1·3	0·3	0·1	0·3	..	0·5	0·4	0·2	0·7	0·1	1·1	1·5	1·4	0·6	0·1	1·0	1·1	0·2	..	..
Paper	29	..	..	..	0·3	0·5	..	1·7	1·5	0·1	..	..	..	0·1	0·7	0·2	..	0·1	0·6	1·2	0·4	0·
Printing and publishing	30	..	..	..	0·1	..	..	4·7	3·9	1·0	0·3	..	..	..	1·5	1·8	..	..	1·0	0·1	0·1	0·
Rubber	31	0·6	..	..	..	..	..	..	..	..	..	..	..	0·7	0·9	6·4	0·1	..	0·3	0·3	0·2	..
Miscellaneous manufactures	32	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·2	..	..	0·2	..	..	..
Building, etc.	33	..	..	..	..	..	..	..	..	..	..	..	0·1	..	..	..	..	..	..	..	..	..
Gas, electricity and water	34	0·4	1·3	0·5	1·5	1·2	0·2	3·3	..	0·4	1·5	0·6	0·4	2·0	1·2	1·3	0·1	0·5	1·9	1·3	0·5	0
Distributive services	35	35·5	3·9	1·0	4·5	1·8	1·3	6·7	2·4	5·3	13·2	4·7	2·1	8·9	5·5	7·5	0·6	2·3	6·3	14·4	7·6	1
Other services	36	0·9	0·6	0·1	0·2	0·1	..	0·2	0·1	0·1	0·4	0·1	0·1	0·5	0·3	0·4	..	0·1	0·4	0·3	0·2	0
Imports	40	18·0	3·8	0·4	1·3	1·7	..	9·8	3·9	28·7	10·8	19·6	0·9	5·2	5·1	3·2	0·3	1·5	37·1	40·8	27·6	0
Unallocated goods and service	41	2·1	6·0	1·9	2·5	..	1·7	2·3	..	1·9	16·5	3·8	0·6	0·6	3·3	5·0	0·6	..	6·1	4·0	3·2	0
Total goods and services		128·1	28·2	5·6	24·4	12·3	13·1	48·4	21·3	53·5	122·0	39·7	24·0	82·6	53·3	99·2	5·9	22·2	101·4	156·4	98·8	28
Incomes and depreciation		172·4	114·8	15·9	37·2	19·5	4·1	42·8	15·3	26·7	69·3	17·0	22·1	101·8	55·0	70·0	8·4	24·4	69·8	50·8	42·4	19
Indirect taxes (net)		−6·7	3·5	0·4	0·6	0·6	0·1	2·0	2·6	1·6	1·9	0·5	0·4	2·5	1·3	2·3	0·1	0·3	2·2	4·2	1·0	0
Total		293·8	146·5	21·9	62·2	32·4	17·3	93·2	39·2	81·8	193·2	57·2	46·5	186·9	109·6	171·5	14·4	44·9	173·4	211·4	142·2	48·

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Relations, U.K., 1935

£ *million*

	Industries														*Final Demand*					
	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37 *Personal Consumption*	38 *Government Consumption*	39 *Fixed Capital Formation*	40 *Exports*	41 *Unallocated, Stocks, Exports, etc.*	*Tota*
	0·4	..	5·9	0·2	41·8	6·0	1·3	0·2	..	..	..	..	..	2·0	0·2	220·7	3·8	..	5·1	1·1	293·8
	0·4	1·3	0·2	0·1	1·7	0·8	0·1	1·6	0·1	0·2	0 2	0·5	20·9	18·2	2·0	35·0	3·0	..	27·8	−1·3	146·5
	..	..	..	..	0·1	..	..	0·4	..	0·1	..	6·0	0·1	..	..	0·2	..	0·4	1·3	1·5	21·9
	..	..	..	..	..	..	0·2	..	..	..	..	37·7	1·3	..	..	2·4	..	3·6	2·5	6·7	62·2
	..	..	..	..	1·6	1·9	0·1	..	..	..	..	6·9	0·1	1·1	..	7·8	0·2	1·3	4·1	0·5	32·4
	..	..	..	..	0·3	..	..	..	0·1	..	..	0·3	0·2	..	..	1·3	..	..	1·9	1·6	17·3
	0·3	4·0	1·4	0·5	1·8	1·4	0·4	1·3	0·1	1·6	0·6	1·9	0·2	..	0·7	23·9	4·8	..	19·4	0·2	93·2
	..	0·2	0·4	0·3	0·5	..	..	0·1	..	..	..	..	..	0·2	0·5	28·5	0·2	..	3·9	2·1	39·2
	0·1	..	0·4	0·3	6·1	..	1·0	0·3	2·3	0·1	1·1	7·3	0·2	4·8	0·4	11·6	1·2	..	9·8	3·6	81·8
	0·1	..	..	..	0·5	..	0·2	..	..	0·3	0·6	22·6	4·0	..	..	4·0	0·1	2·0	25·0	8·7	193·2
	..	..	..	..	0·9	0·2	..	..	0·6	..	0·1	4·8	0·1	..	..	0·7	..	0·5	13·0	1·6	57·2
	..	..	..	..	..	..	..	..	..	..	..	..	..	7·0	..	0·2	15·9	12·4	10·6	0·2	46·5
	0·2	0·3	..	..	0·2	0·1	..	0·3	0·6	..	..	12·5	3·6	..	..	3·5	12·9	68·3	34·2	9·1	186·9
	..	..	..	..	..	..	..	..	..	..	..	6·3	10·0	..	..	22·1	0·7	27·5	13·7	6·5	109·6
	..	..	..	..	..	..	..	..	..	..	0·1	0·4	..	9·4	..	53·6	2·3	39·4	15·8	9·4	171·5
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	8·3	2·3	2·6	..	14·4
	..	..	..	..	..	..	..	..	..	..	..	1·2	..	22·3	..	..	..	15·3	1·9	..	44·9
	0·1	..	0·5	1·6	4·3	0·9	3·9	0·2	0·1	0·2	0·8	12·1	0·4	0·1	..	32·3	1·6	2·2	45·2	23·6	173·4
	3·1	..	0·4	31·1	0·1	..	1·7	0·1	0·5	3·4	0·9	..	..	5·0	..	21·2	0·1	..	60·2	1·8	211·4
	1·0	..	0·1	27·1	..	..	2·5	..	..	..	0·3	..	..	4·0	..	21·6	..	..	32·8	0·6	142·2
	..	..	..	2·8	..	..	..	..	..	..	..	..	..	0·2	..	37·5	..	..	5·0	0·2	48·4
	14·5	0·1	..	3·0	1·0	..	1·7	0·7	..	..	0·8	0·9	..	4·0	..	8·1	0·2	..	15·1	3·0	61·1
	1·6	0·5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	32·1
	0·2	..	8·5	14·0	..	..	0·6	..	0·1	..	0·1	..	..	0·8	..	12·0	0·1	..	4·6	0·9	47·1
	..	..	..	12·9	..	..	..	..	..	..	..	..	..	1·5	0·5	197·9	1·2	..	7·7	0·7	222·4
	..	..	..	..	56·6	2·8	..	..	..	..	..	0·2	..	0·8	..	286·3	3·5	..	13·5	0·3	406·0
	..	..	..	..	0·8	50·7	..	..	..	..	..	..	..	0·3	..	288·8	..	..	10·3	7·6	360·8
	0·1	0·2	..	0·4	1·5	2·1	8·9	0·1	..	..	0·6	14·0	0·1	1·5	..	41·9	2·0	2·5	1·1	9·0	98·6
	0·1	0·4	0·1	1·2	5·6	3·5	0·3	9·7	18·1	0·1	0·3	1·3	..	5·5	..	8·2	1·2	..	6·2	5·0	74·8
	0·3	..	..	1·5	4·6	3·9	0·4	0·6	7·0	0·3	0·2	..	0·9	29·0	12·0	46·7	4·3	..	4·5	14·7	145·7
	0·3	..	..	2·1	..	..	..	..	..	0·2	0·2	0·2	..	..	..	9·4	0·1	..	4·7	- 1·7	28·4
	..	..	0·2	..	..	..	0·1	..	0·1	..	0·4	0·6	0·2	..	1·8	14·6	0·2	..	4·2	1·4	24·2
	..	..	..	..	..	..	..	..	..	..	..	22·9	..	31·1	95·0	0·4	54·3	266·3	..	0·5	470·6
	0·4	0·4	0·2	1·1	8·7	0·9	0·7	0·6	0·9	0·5	0·1	1·0	35·4	15·8	2·5	93·1	11·7	34·7	1·6	11·8	242·5
	3·2	1·7	2·0	9·2	23·9	10·3	5·6	4·3	5·9	1·2	1·5	22·4	12·8	115·0	46·0	1,072·0	20·1	26·2	145·0	35·1	1,700·6
	0·1	0·1	0·1	0·5	0·6	0·5	0·2	0·2	0·5	0·1	0·1	10·0	1·8	15·0	8·0	835·0	283·5	..	187·0	..	1,348·5
	10·3	1·3	11·2	10·4	91·2	20·3	19·5	16·1	4·5	5·4	1·9	18·5	0·7	10·8	7·7	265·8	7·7	13·6	52·4	13·1	802·2
	4·7	2·7	1·0	2·2	10·6	..	2·7	3·3	0·6	0·8	1·4	0·2	..	20·0	10·0	−4·8	2·9	−7·7	14·5	5·1	132·4
	41·5	13·2	32·6	122·5	265·0	106·3	52·1	40·1	42·1	14·5	12·3	212·7	93·0	325·4	187·3	3,703·6	448·1	510·8	808·2	187·5	8,385·9
	18·7	18·5	13·9	94·8	119·7	92·9	43·9	33·3	101·6	13·6	11·7	252·6	148·6	1,271·6	1,008·8	..	..	..	..	−17·9	4,225·2
	0·9	0·4	0·6	5·1	21·3	161·6	2·6	1·4	2·0	0·3	0·2	5·3	0·9	103·6	152·4	84·8	2·4	1·7	..	17·9	587·3
	61·1	32·1	47·1	222·4	406·0	360·8	98·6	74·8	145·7	28·4	24·2	470·6	242·5	1,700·6	1,348·5	3,788·4	450·5	512·5	808·2	187·5	13,198·4

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4.30. The percentages relating to a few of the industries become somewhat higher if unallocated input is related to output exclusive of intra-industry transactions. Further, since the estimate for value added is a comparatively firm one (being based on the "net output" of the census), it is interesting to relate unallocated input to the input of goods and services only, and to take the latter exclusive of intra-industry transactions. The average unallocated is then 6 per cent. with the following frequency distribution:

Percentage of Input of Goods and Services Unallocated	*Number of Industries*	*Amount Unallocated* (£ *mn.*)
0–2	11	5·8
3–5	5	18·1
6–10	8	33·4*
11–15	7	33·3†
16–20	1	4·7
21–25	2	19·2
26–30	1	6·0
31–35	1	1·9
Total . .	36	122·4

* Including £10 mn. for "other service industries".
† Including £20 mn. for "distributive industries".

4.31. In the case of the three industries (coal mining, other mining and iron and steel) showing the highest proportion of input unallocated, with a total amount of £24 mn. unallocated, it seems reasonable to suppose that certain capital goods, such as mine tubs, have been recorded in the census of production as current input. The two industries showing the next highest proportion are textile finishing and "other textiles", and there may be a certain amount of further transactions between the textile industries which, in view of the complicated organization of these industries and the inadequacy of the census returns, may have escaped attention. In these industries, consisting of many relatively small firms and performing a number of not very homogeneous activities, it is very difficult to supplement the census tabulations by outside data.

4.32. The output of industry remaining unallocated (which includes stock change) was significant only in a few instances. The industries concerned were motor and cycle (because of repairs), metal goods (chains, nails, etc.), wood (for packing), paper (for packing), and printing (advertising material and stationery), gas, electricity and water (non-domestic water), and the distributive industries (on account of the distributive margin on unallocated commodities). In all these cases the unallocated product is widely distributed between industries and no allocation is possible without a detailed inquiry.

The Transaction Matrix

4.33. The total amount of transactions recorded in Table 7 came to £13,198 mn. and can be divided into four categories, contained in the four rectangles of the table indicated by thick lines. The final output of industry as a whole was £5,296 mn., and this was, by definition, also the value of primary input into industry; the direct use of primary input for final output (mainly imports directly consumed or re-exported) was £451 mn.; and transactions within the field of industry amounted to £2,156 mn. Of the latter £622 mn. was accounted for by intra-industry transactions on the definitions adopted (the sum of figures along the diagonal) and £1,534 mn. by inter-industry transactions proper.

4.34. Alternatively, the total of transactions (eliminating intra-industry transactions) can be divided into the output of industry (£6,830 mn.) and final output (£5,747 mn.). On the monetary side final output arises in the following way:

	£ million
Expenditure on gross national product	4,813
Expenditure *less* net borrowing in the United Kingdom by overseas residents and governments	802
Expenditure on unallocated goods and services . . .	132
Expenditure on final output	£5,747

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The monetary equivalent of the output of industry is disbursed in the following way:

	£ million
Payments for goods and services—	
To overseas residents and governments	450
To other industries	1,534
Depreciation allowances	240
Indirect taxes *less* subsidies	498
Income payments (wages, profits, etc.)	3,985
Unallocated goods and services	122
	£6,830

The gross national product is equivalent to disbursements by industry for income payments, for depreciation allowances and for net indirect taxes, but an addition has to be made for those indirect taxes which were recorded in the table as if they were direct taxes (mainly customs duties on imports for direct consumption).

4.35. The relatively small volume of inter-industry transactions is due to the fact that, in the case of Britain, a large proportion of goods and services used as input (23 per cent.) was imported; further, that depreciation allowances were included in value added instead of their physical equivalent entered as goods used up; and only to a smaller extent to the unallocated item. Indirect taxes also cause a complication, but the great majority of them is almost directly passed on to consumers (such as the tobacco duty) and could be eliminated. In a closed economy, with no indirect taxes, and with depreciation entered as physical input, inter-industry transactions might be of the order of £1,770 mn.* out of a total of £9,740 mn.† For a number of purposes use can be made of Table 6, which shows the commodity composition of input irrespective of whether it consists of imports or domestic production.

* 1,534 + 240.
† Twice the net national income (3,985) plus 1,770.

TABLE 8

Summary of Inter-industry Relations, United Kingdom, 1935

£ million

From: \ *To:*		*Industries*										*Consumption*	*Capital Formation*	*Exports*	*Stocks and Unallocated*	*Total*	*Rounding off Error*
		1	2	3	4	5	6	7	8	9	10						
Agriculture and food	1	..	..	2	4	8	..	..	..	..	3	803	..	29	9	858	..
Coal and power	2	14	..	12	8	9	4	16	8	3	39	144	35	31	12	334	..
Building, building materials and timber	3	10	3	..	5	1	1	7	10	2	129	109	274	9	18	577	..
Chemicals and rubber	4	25	2	14	..	13	6	2	19	3	7	80	..	38	8	217	..
Textiles and clothing	5	4	..	8	5	..	4	..	8	..	16	300	..	125	7	476	+1
Paper, printing and miscellaneous	6	18	1	4	13	6	..	..	5	2	48	75	..	15	21	208	..
Metal making	7	2	5	28	3	..	1	..	62	30	..	5	3	38	10	188	−1
Engineering	8	5	16	21	..	4	1	2	..	1	39	120	165	79	25	477	+1
Metal goods, n.e.s.	9	7	1	16	5	3	1	2	22	..	..	34	2	45	24	162	..
Services	10	72	20	46	16	41	13	18	28	7	..	2,211	26	332	35	2,865	..
Imports		130	5	41	48	102	23	30	16	37	19	274	14	52	13	802	+2
Unallocated		13	8	7	5	18	5	20	10	6	30	−2	−8	15	5	132	..
Incomes and depreciation		385	268	369	98	258	147	86	282	70	2,280	..	..	..	−18	4,225	..
Indirect taxes		176	5	10	7	13	4	2	7	2	256	87	2	..	18	587	+2
Total		858	334	577	217	476	208	188	477	162	2,865	4,239	513	808	188	12,108	+6
Rounding off error		+3	..	+1	..	..	+2	−3	..	+1	+1	+1	..	..	−1	..	..

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4.36. The magnitude of inter-industry transactions also depends on the success of the industrial classification. Given the number of industries distinguished, the more successful classification reduces the volume of transactions between separate industries, and this appears to be the case at present. Hence in the application of the model, the primary effects of a change in the pattern of output or of prices (that is, the effect on the industry directly concerned with the change) will be large in relation to the secondary effects; consequently, more accurate results are obtainable, since the primary effects can be adjusted by knowledge derived from data not incorporated in the model.

4.37. As an experiment, the number of industries was reduced from 36 to 10 as shown in Table 8. This consolidation diminishes inter-industry transactions from £1,534 mn. to £1,069 mn. The main factors in this reduction are the consolidation of textiles and clothing (about £140 mn.), of agriculture and food (about £90 mn.), and of building, building materials and timber (about £60 mn.). A further reduction to three industries only, investment goods (nos. 2, 3, 7, 8 and 9 of Table 8), consumption goods (nos. 1, 4, 5 and 6) and services (no. 10) would still leave inter-industry transactions at £697 mn. The schedule of transactions between these three industries is given in Table 9.

TABLE 9

Inter-industry Relations for Three Groups (£ *million*)

	Industry of Destination		
Industry of Origin	*Investment Goods*	*Consumption Goods*	*Services*
Investment goods . .	—	84	207
Consumption goods .	70	—	74
Services . . .	120	142	—

The hard core is provided by the service industries, which account for £544 mn. of the transactions. Without the service industries the amount of transactions would have been the following (in £ mn.):

Between	34	industries	(Table 7) . .	990
,,	9	,,	(Table 8) . .	527
,,	2	,,	(Table 9) . .	154

4.38. It is difficult to come to any general conclusion from this examination. It seems that consolidation of industries is possible, since groups of industries can be found with stronger than average interdependence within them. On the other hand interdependence pervades practically the whole area of the economy, and consequently only a limited advance can be made through consolidation. Starting from 36 industries, on balance it does not appear that the further gain in simplicity would outweigh the disadvantage of an increased divorce from reality.

4.39. Table 8 makes it clear that certain industries, like coal and power, or chemicals, cannot be further consolidated with other industries as they are equally interdependent with consumption and investment goods industries. Further, any *vertical* consolidation (such as textiles and clothing) makes the relationship of imports or exports to output more unrealistic. Trade takes place at various stages of production, and generally imports are heavy at the early and exports at the later stages, but not necessarily at the latest stage (for instance, clothing). With excessive vertical consolidation both imports and exports are likely to be related to unsuitable quantities.

Characteristics of Different Industries

4.40. Some characteristics of the industries distinguished in Table 7 are further analysed in Table 10. The size of industries varies enormously; on the one hand, in the service industries, building, mechanical engineering, and agriculture, no further breakdown was feasible, and coal

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mining is regarded as homogeneous; on the other hand the smaller industries are not similar to any other and distribute their output over a wide field.*

4.41. One result of consolidating activities into industries is that the proportion of value added (roughly corresponding to "net output" in the census of production) increased in relation

TABLE 10

Output by Industry and the Percentage Share of Value Added, Final Output, Exports and Imports, United Kingdom, 1935

Industry Number		(*a*) *Output* £ *mn.*	(*b*) *Value added* (%)	(*c*) *Final output* (%)	*Exports* (%)	*Imports* (%)	*Exports less Imports* (%)
1	Agriculture, forestry, etc.	293	57	78	2	6	−4
2	Coal mining	141	84	47	20	3	17
3	Other mining	22	74	9	6	2	4
4	Building materials	59	64	14	4	2	2
5	China, glass	31	65	43	13	5	8
6	Coke ovens	17	24	19	11	..	11
7	Chemicals, etc.	87	52	55	22	11	11
8	Soap, polishes	38	48	86	10	8	2
9	Oils, paints	76	38	30	13	38	−25
10	Iron and steel manufacturing	141	51	22	18	8	10
11	Non-ferrous metals	51	34	28	25	38	−13
12	Shipbuilding	46	49	85	23	2	21
13	Mechanical engineering	171	61	70	20	3	17
14	Electrical engineering	97	58	65	14	5	9
15	Motor and cycle	135	53	82	12	2	10
16	Aircraft	13	64	100	20	2	18
17	Railway rolling stock	44	57	39	4	3	1
18	Metal goods, n.e.s.	162	44	50	28	23	5
19	Cotton and silk	148	37	55	41	28	13
20	Woollen and worsted	100	43	55	33	28	5
21	Hosiery and lace	46	43	92	11	..	11
22	Other textiles	47	42	50	32	22	10
23	Textile finishing, etc.	32	60	..	..	4	−4
24	Leather and fur	39	38	43	12	29	−17
25	Clothing	210	48	99	4	5	−1
26	Food processing	349	40	87	4	26	−22
27	Drink and tobacco	310	82	96	3	6	−3
28	Manufactures of wood	90	52	53	1	22	−21
29	Paper	65	53	24	10	25	−15
30	Printing and publishing	139	75	40	3	3	..
31	Rubber	28	49	51	17	19	−2
32	Miscellaneous manufacturing	24	50	79	18	8	10
33	Building, etc.	448	58	72	..	4	−4
34	Gas, electricity and water	207	72	68	1	..	1
35	Distributive services	1,585	87	80	9	1	8
36	Other private services	1,341	87	97	14	1	13
	Total	6,832	69	75	11	11	..

(*a*) Excluding intra-industry transactions.
(*b*) Incomes, depreciations and taxes.
(*c*) Consumption, fixed capital formation and exports.

* In the case of aircraft, the growth of the industry subsequent to 1935 was the reason for separation.

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to output, and for a 36 industry model it averaged 69 per cent. Value added was a particularly high proportion (72–87 per cent.) in the two mining industries, in drink and tobacco, in printing, in gas, electricity and water, and in the two service industries. The reasons for this are not the same in each case; high labour intensity is the explanation in mining, capital intensity in public utilities, and taxes in drink and tobacco. The lowest proportions (24–38 per cent.) are found in the coke, oils and paints, iron and steel, cotton and leather industries, where comparatively large volumes of raw materials are subjected to processing which is well established and relatively simple.

4.42. As a corollary of the high proportion of value added, the proportion of final output also increases with consolidation and it averaged 75 per cent. The proportion was particularly high—over 90 per cent.—in aircraft, clothing, hosiery, drink and tobacco and "other services"; it was over 80 per cent. in food, soap and polishes, shipbuilding and the motor industry. All these are industries producing almost exclusively finished consumer or capital goods. At the other end of the scale, with proportions below 30 per cent., are textile finishing, "other mining", building materials, paper, iron and steel, non-ferrous metals and coke, all producing predominantly intermediate products which, in each case, are used by a number of other industries.

4.43. On the average 11 per cent. was exported of the output of industries. Cotton leads with 41 per cent., followed by wool (33 per cent.) and other textiles (32 per cent.). The proportions are also high (20–29 per cent.) for coal, coke, chemicals, non-ferrous metals, shipbuilding, mechanical engineering, aircraft and metal goods n.e.s. At the other end of the scale, with less than 5 per cent. of output exported, are agriculture, building materials, railway rolling stock, textile finishing, clothing, food, drink and tobacco, wood, printing, building and public utilities. Some of these industries are local industries (like building) and some are producing finished goods (like clothing).*

4.44. Imports on the average contributed 11 per cent. to the value of output. The proportion was highest in the case of oils and non-ferrous metals (38 per cent.), leather (29 per cent.), cotton and wool (both 28 per cent.), food (26 per cent.) and paper (25 per cent.). Lowest for coke and public utilities (0), the two service industries (1), coal and other mining, building materials, the engineering industries, hosiery, textile finishing, printing and building (2–5). The remarkable fact is that industries which relied most heavily on imports also contributed substantially to exports; cotton, wool, other textiles, and metal goods n.e.s., more than covered their own import requirements by exports, and the *net* deficit was heavy (over 20 per cent. of output) only for oils and paints, food processing and wood manufactures. Industries with one-way relations with overseas countries (such as coke) were as frequent as industries with two-way relations (such as rubber).

Acknowledgment

4.45. This study has involved a very large amount of computation and collation of data. It has been possible only because of generous assistance provided by the Economic Research Division at the London School of Economics (where the study originated in 1946) and by Nuffield College, Oxford, and because of advice received from government departments and business firms. Professor R. G. D. Allen has maintained a constant interest in the progress of the study, and, among several research assistants employed, I would particularly mention L. S. Berman, whose contributions amount almost to general collaboration in the study. I must, however, accept sole responsibility for this presentation of the work.

5. *Qualifications and Conclusions*

5.1. The limitations on the application to real problems of the model defined and evaluated in the preceding sections spring from three distinct sources: the estimates may be inaccurate or inadequate; they may be estimates relating to unsuitable concepts; or the assumptions on which the operation of the model rests may be unrealistic.

* The proportion for drink and tobacco would be over 5 per cent. if account were taken of the fact that no duty falls on exports.

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Errors in the Estimates

5.2. It has become customary in the presentation of data of this nature to indicate margins of error. The computations were in fact carried out, as stated above, for a detailed list of industries, and individual entries related to particular commodities. Each entry was allotted one of five letters indicating the reliability of the estimates. Because of the nature of the estimates, however, a complicated pattern of interdependence exists between the errors themselves, and to date no estimates were made to compound the errors of the elementary estimates into margins to be attached to the figures in the tables.

5.3. A great deal of uncertainty arises from the fact that it is not known how the census of production questionnaires were interpreted by those returning them; in particular, it is not known to what extent transporting and selling activities were included, how far office expenses (like stationery) were covered, and how the dividing line was drawn between current and capital expenditure. The errors arising from this source could be reduced with more detailed instructions issued with the census forms (as was done since the war) and with special information obtained from individual firms (as was done in a few cases for purposes of the present inquiry). Another important source of error lies in the difficulty of interpretation of the census tabulations without reference to the individual returns in the case of industries where the organization of production is complex, with establishments supplying each other, and where it is difficult to know how far input may consist of semi-finished products; the motor-car industry is a case where the estimates given here differ substantially from the officially published estimate of "duplication" in the value of "gross output".

5.4. It was also, unfortunately, the case that relatively few independent estimates of final output or primary input were available. The statistics of exports and imports are well known and form an exception; even here, however, unexpected difficulties were encountered when an exhaustive classification was attempted, parallel with the classification of domestic production, and when values (as, for instance, of imports of the more expensive metals) were compared with census of production results. Also, all classifications have unspecified items, and there is no reason to assume that unspecified output, imports and exports consist of identical commodities. The greatest drawback, however, was the lack of independent estimates for the bulk of consumption and capital formation; in fact, the official estimates for 1938 were largely derived from precisely those statistics which were used here, that is, they are residual items of output statistics. As an experiment, an attempt was made to reconcile census of production returns for railway equipment and construction with the accounts of railway companies, but the uninitiated cannot go very far by this method. For government consumption, an apparently detailed set of statistics is available in the appropriation accounts. But it is well known to students of government finance that it is not at all simple to extract from those accounts anything directly useful to the present inquiry; the difficulties are even greater with local authority expenditure, where one has to fall back on the returns of each individual authority. On stocks of commodities, with the exception of stocks in bond, practically nothing was known, and therefore it is not possible to tell, industry by industry, the size of the residual error in the estimates; for commodities which were consumption goods any residual error would be included in the estimate of personal consumption, for investment goods in capital formation, and for producers' goods in the item "stocks and unallocated". If stocks had been the only residual item this would not matter: stock change in a sense represents the errors in planning, and it does no harm for the operation of the model if errors in planning and those in statistics are lumped together. Lastly, no attempt was made to split value added between its components—wages, salaries, profits, interest, rent, depreciation and taxes—as this was not immediately wanted; but for certain problems an evaluation, particularly of wages, would become necessary.

The Relevance of the Concepts Used

5.5. On the question as to how far were relevant concepts considered, the main doubt arises from the fact that the input coefficients proper, as obtainable from Table 7, exclude imports and capital goods. The problems arising from a significant level of imports of intermediate

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commodities—which could be neglected in studies dealing with the United States—have not yet been solved. The estimates in Table 7, as they are, are relevant for the solution of problems which assume that import propensities do not change; if, however, one wants to know the structure of industry which would obtain without imports, one would have to rely on coefficients derived from Table 6. Clearly neither method is entirely satisfactory, and in fact one wants something between the two. Import propensities do change, and indeed many policy measures aim at changing them; if devaluation is discussed, for instance, it would not be legitimate to assume that the import propensity of each industry remained unchanged. On the other hand, the model derived from Table 6 would assume that imports are fully competitive with home production; that is, it would be assumed that the equilibrium level of agriculture would result in an appropriate output of, among other things, cotton, tobacco and tea, and this again is absurd. But these questions remain to be investigated on another occasion.

5.6. The neglect of the input of capital goods has more than one aspect: capital is a stock which is gradually used up in the process of production, and thus it is necessary to know both the input of capital consumption per unit of output and the stock of capital. With the neglect of these factors the model can function only on the assumption that excess capacity exists all round, or that capacity will somehow be looked after. In order to consider economic development and long-term costs of production this is an unsatisfactory solution. Capital consumption must be taken into account even if one works in terms of simple physical concepts, such as the labour content of output; but of two alternative methods of production with an identical set of input coefficients, including the coefficient for capital consumption, the one using a smaller stock of capital would be preferable. The higher output resulting from more capital intensive methods of production must be balanced against the cost of producing capital; the resulting cost item—interest, or the classical economist's "waiting" (which should be kept separate from capital consumption)—represents, however, a primary commodity distinct from labour, and hence problems of allocating more than one primary commodity would arise.

Input Coefficients

5.7. The most important limitations are, however, those imposed by the assumption relating to the input coefficients, even in the event of these referring to the appropriate concepts and being accurately measured. The input coefficients of an industry can change for four distinct reasons: (*a*) as the result of technological progress (or through exhaustion of natural resources), (*b*) change in the composition of the output of the industry, (*c*) increasing or diminishing returns to scale, (*d*) substitution of one input for another.

5.8. It would be absurd to suggest that the input coefficients be kept constant irrespective of the problems that are considered. If longer term problems are considered, due allowance must be and can be made for expected changes caused by technological progress. With modern industry, which is to a large extent based on organized research, most inventions can be anticipated and, on the basis of such knowledge as is possessed by technicians, the current input coefficients may be adjusted.

5.9. It is possible to eliminate, to a large extent, the disturbances caused by a change in the composition of output by a more refined classification of industries. It is not suggested that for each problem several hundred industries should be distinguished; but statistical material in sufficient detail should be available to re-arrange the classification in relation to the particular problem considered. But, again, why should the composition of output change suddenly? It may change as the indirect consequence of technological change, but normally, on a suitable classification, it would be safe to deal with a limited number of industries.

5.10. Increasing or diminishing returns are largely a matter of definition. In dealing with long-term inputs, it is fairly reasonable to assume that most of modern industry operates under constant returns. If the scale of the industry changes without a change in the number of firms, certain input coefficients, in the short-run in the nature of overheads, may be falling with an increase in scale, but others, mainly those connected with selling, would rise, and the two would cancel. Otherwise, the number of firms might change and the industry would then strictly reproduce itself in its entirety.

5.11. The most difficult problem is raised by the substitution of one input for another as the

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result of price changes. In a static and closed economy the structure of industry can change only in respose to spontanenous changes in the pattern of final output, or spontaneous changes in factor prices. In so far as economies of scale are ruled out, changes in the pattern of final output can hardly affect prices, and thus cannot bring about substitution without a simultaneous change in factor prices. As far as factor prices are concerned, no problem can arise when competitive conditions have established stable price relatives. Monopolistic pricing can, however, cause arbitrary changes as monopoly power shifts, to a large extent as the result of shifts in demand. It is possible to ignore this problem only on the assumption that long-term wage relatives and profit margins are stable; whether this stability is the result of competition, or established monopolistic practices, is not relevant. A good deal of empirical evidence does exist, however, to support this assumption.

5.12. But the real economy is not static and, at any rate in Britain, not closed; here prices change because of technological change and because of changes in the terms of trade, and both bring in their train a chain of repercussions. It cannot be pretended that in these circumstances the model would yield exact results: the question is whether it will yield useful results. By assuming no substitution to take place as a repercussion to price changes, valuable results may be obtained which possess the qualities of first approximation; adjustments can be made to refine them, and they certainly might show the direction in which the economy moves. It is a recognized scientific procedure to build general models on simplifying assumptions as a means of bringing out certain important relations, and of supplying a base on which further work can be built.

5.13. But with modern technology substitution is not such a formidable possibility as suggested by the continuous production opportunity curves of economic textbooks. When a factory is set up a decision has to be made on the methods of production to be used, and this largely determines the input coefficients. A change can be made only through important alterations in equipment, and the nearest alternative set of input coefficients is usually a good deal different from the first. It is thus possible to consider in connection with each industry a finite (and relatively small) number of alternative input coefficients, and examine which of these would be most profitable under a given set of prices. Beginnings have been made in use of this technique in order to generalize the application of inter-industry relations models (Koopmans, editor, 1951).

Conclusion

5.14. This inquiry served two main purposes: it investigated the nature of statistical data available for a study of inter-industry relations in the United Kingdom, and it established certain estimates with which it will be possible to compare similar estimates in respect of some other year. It was shown that even with 1935 data one could estimate inter-industry transactions fairly exhaustively. The relationships which were important in the particular circumstances of Britain were demonstrated, and the weaknesses in the body of statistical information that was available were made note of. For practical purposes, however, it must be admitted that the British economy has moved a long way since 1935, and it would be more directly useful to obtain estimates of current validity. Since the war new materials and new commodities were developed, the young industries of 1935—like rayon, plastics, and a vast range of chemicals—have grown up, and in technology a new industrial revolution is being talked of; but at the same time, the massive older industries —coal, cotton, steel, paper or bricks—continue very much as before, and the relative importance of what has changed to what remained unchanged still has to be investigated. When an inquiry for 1948, possibly on a fuller scale, is undertaken, one will see more clearly the changes that the British economy underwent during and after the war; a comparison between two years, as far apart as 1935 and 1948 should be particularly valuable to test the stability of certain relationships, on which depends the validity of the operation of the model.

6. *Appendix A: Industrial Classification*

6.1. In Tables 5, 6, 7 and 10 activities were divided into 36 industries, details of which are given below. The Census of Population, 1931, distinguished 22 industrial orders, the last containing unclassified industries. The connection between the present classification and that of

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the Census of Population is the following, together with the estimated number of persons engaged (including unemployed) in each major category in 1935:

	Industry Number	*Census of Population Industry Order*	*Estimated Number of Persons Engaged (Millions)*
Agriculture, etc.	1	I–II	1·5
Mining, manufacturing and construction*	2–34	III–XV	10·3
Distributive industries	35	XVI–XVII	5·1
Other service industries	36	XVIII–XXI	5·7
Other industries	..	XXII	0·2
Total			22·8

* Covered by the Census of Production, 1935.

6.2. Industries were divided into trades as listed below (numbered in italics), and the original estimates were prepared separately in respect of each trade. Trades Nos. *2* (allotments and back-yards), *156* (management of dwellings, etc.) and *157* (management of overseas investments) are largely fictitious, in so far as no Census of Population industry corresponds to them; the output of these trades consists respectively of food, services of dwellings as measured by gross rent, and services of overseas investment as measured by interest and profits. Trades Nos. *1–4* are covered by Ministry of Agriculture statistics (except that inland fisheries, which are negligible, were ignored), trades Nos. *5–142* by the Census of Production, 1935, but the estimates for trades Nos. *143–157* are, with few exceptions, largely conjectural. The numbering of trades from *5* to *142* follows the order of the Census of Production. Trades Nos. *127–142* consist of the producing establishments of government departments and most of them were comparatively small. This breakdown corresponds to the maximum allowed by the Census of Production except that repairs of motor cars and cycles, and of boots and shoes, were not distinguished from new production. The Census of Production published details for sections of some of the larger trades, but not sufficient detail for a subdivision of these trades in the present study.

6.3. The commodity classes corresponding to industries 2–34 are defined as consisting of the "principal products" of these industries in the Census of Production, with certain exceptions. All iron and steel forgings, railway wheels and axles were put under iron and steel, including those put by the Census under metal goods n.e.s., and railway rolling stock; benzol mixed with petrol was dealt with together with petroleum products and not with chemicals; gas coke was dealt with together with coke-oven coke and not with gas and electricity. The Census (which was unrevised because of the war) omitted from "principal products" certain items, although they were included in "other output", and a correction was made for this; these were wire mattresses (trade *35*), copper wire (*38*), some printing work (*110*), and clay sold (*116*). The distinction made between imported hewn and sawn timber is subject to doubt, and therefore both were put under manufactures of wood. Agricultural commodities include non-agricultural horses for export and hair which is the by-product of leather tanning.

6.4. The list of industries is as follows:

Industry Number	*Trade Number*	
1		Agriculture, forestry and fishing:
	1	Agriculture and horticulture.
	2	Allotments and back-yards.
	3	Fishing.
	4	Forestry.
2		Coal mining:
	115	Coal mines.
3		Other mining:
	116	Non-metalliferous mines and quarries (other than *115*, *118* and *119*).
	117	Metalliferous mines and quarries.
	118	Slate mines and quarries.
	119	Salt mines, brine pits and salt works.

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Industry Number	*Trade Number*	
4		Building materials, etc.:
	20	Roofing felt.
	94	Manufactured abrasives.
	98	Brick and fireclay.
	101	Cement.
	102	Building materials.
5		China, glass, etc.:
	99	China and earthenware.
	100	Glass.
6		Coke ovens, etc.:
	87	Coke and by-products.
	88	Manufactured fuel.
7		Chemicals, etc.:
	73	Chemicals, dyestuffs and drugs.
	74	Fertilizer, disinfectant, glue, etc.
	80	Explosives and fireworks.
	86	Plastic materials, buttons and fancy articles.
8		Soap, polishes, etc.:
	75	Soap, candle and perfumery.
	81	Starch and polishes.
	82	Match.
9		Oils and paint:
	76	Paint, colour and varnish.
	77	Seed crushing.
	78	Oil and tallow.
	79	Petroleum.
	83	Ink, gum and typewriter requisites.
10		Iron and steel:
	31	Iron and steel (blast furnaces).
	32	,, ,, (smelting and rolling).
	33	,, ,, (foundries).
	34	Tinplate.
	37	Wrought iron and steel tube.
11		Non-ferrous metals:
	50	Copper and brass (smelting, rolling, etc.).
	51	Aluminium, lead, tin, etc. (smelting, rolling, etc.).
12		Shipbuilding:
	45	Shipbuilding.
	127	Government departments: Admiralty (Naval dockyards).
13		Mechanical engineering:
	42	Small arms.
	43	Mechanical engineering.
	128	Government departments: Admiralty (Naval ordnance factories).
	135	,, ,, War Office (Ordnance factories).
14		Electrical engineering:
	44	Electrical engineering.
	133(a)	Government departments: G.P.O. (Telephone and Telegraph) (workshops only).
15		Motor and cycle:
	46	Motor and cycle.
16		Aircraft:
	47	Aircraft.
	138	Government departments, Air Ministry: R.A.F. works.
	139	,, ,, ,, ,, Royal Airship works.

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Industry Number	*Trade Number*	
17		Railway rolling stock:
	48	Railway carriage and wagon building.
	124(a)	Railway companies (workshops only).
	125(a)	Tramway and light railway companies (workshops only).
18		Metal goods, not elsewhere specified:
	35	Hardware, hollow-ware, metallic furniture and sheet metal.
	36	Chain, nail, screw and miscellaneous forgings.
	38	Wire.
	39	Tool and implement.
	40	Cutlery.
	41	Needle, pin and metal small-wares.
	49	Carriage, cart and wagon.
	52	Gold and silver refining.
	53	Finished brass.
	54	Plate and jewellery.
	55	Watch and clock.
	85	Scientific instruments, appliances and apparatus.
	90	Musical instruments.
19		Cotton and silk textiles:
	5	Cotton (spinning and doubling).
	6	Cotton (weaving).
	8	Silk and artificial silk.
20		Woollen and worsted:
	7	Woollen and worsted.
21		Hosiery and lace:
	11	Hosiery.
	13	Lace.
22		Other textiles:
	9	Linen and hemp.
	10	Jute.
	14	Rope, twine and net.
	15	Canvas goods and sack.
	16	Asbestos goods and engine and boiler packing.
	17	Flock and rag.
	18	Elastic webbing.
	19	Coir fibre, horse-hair and feather.
23		Textile finishing and packing:
	12	Textile finishing.
	21	Packing.
24		Leather and fur:
	22	Fellmongery.
	23	Leather (tanning and dressing).
	24	Leather goods.
	29	Fur.
25		Clothing:
	25	Tailoring, dressmaking, millinery, etc.
	26	Boot and shoe.
	27	Hat and cap.
	28	Glove.
	30	Umbrella and walking stick.
26		Food processing:
	56	Grain milling.
	57	Bread, cakes, etc.
	58	Biscuit.

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Industry Number	*Trade Number*	
	59	Cocoa and sugar confectionery.
	60	Preserved foods.
	61	Bacon curing and sausage.
	62	Butter, cheese, condensed milk and margarine.
	63	Sugar and glucose.
	64	Fish curing.
	65	Cattle, dog and poultry food.
	66	Ice.
	131	Government departments: Admiralty (Naval victualling yards).
	136	,, ,, War Office (Army bakeries).
27		Drink and tobacco:
	67	Brewing and malting.
	68	Spirit distilling.
	69	Spirit rectifying, compounding and methylating.
	70	Aerated water, cider, vinegar and British wine.
	71	Wholesale bottling.
	72	Tobacco.
28		Manufacture of wood:
	103	Timber (saw-milling, etc.).
	104	Furniture and upholstery.
	105	Coopering.
	106	Cane and wicker furniture and basketware.
	107	Wooden crates, cases, boxes and trunks.
29		Paper:
	108	Paper.
	109	Wallpaper.
	111	Manufactured stationery.
	113	Cardboard box.
30		Printing and publishing:
	110	Printing, bookbinding, stereotyping, engraving and kindred trades.
	112	Printing and publication of newspapers and periodicals.
	132	Government departments: Admiralty (Chart establishment).
	140	,, ,, H.M. Stationery Office.
	142	,, ,, Ordnance Survey Department.
31		Rubber:
	84	Rubber.
32		Miscellaneous manufacturing:
	89	Linoleum and oilcloth.
	91	Brush.
	92	Games and toys.
	93	Sports requisites.
	95	Incandescent mantles.
	96	Cinematograph film printing.
	114	Pens, pencils and artists' materials.
	134	Government departments: G.P.O. (other departments).
33		Building and civil engineering:
	97	Building and contracting.
	120	Local authorities.
	124(b)	Railway companies (construction only).
	125(b)	Tramway and light railway companies (construction only).
	126	Canal, dock and harbour companies.
	129	Government departments: Admiralty (Civil Engineering Department).
	133(b)	,, ,, G.P.O. (Telephone and Telegraph) (construction only).
	141	,, ,, H.M. Office of Works.

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Industry Number	*Trade Number*	
34		Gas, electricity and water:
	121	Gas undertakings.
	122	Electricity undertakings.
	123	Water undertakings.
	130	Government departments: Admiralty (Electricity undertaking).
	137	,, ,, War Office (,, ,,).
35		Distributive industries:
	143	Railways.
	144	Shipping.
	145	Other transport and storage.
	146	Communications.
	147	Distributive trades.
	148	Insurance.
	149	Banking, finance, estate, etc., agents.
	150	Advertising, etc., agents.
36		Other service industries:
	151	Professions (religion, medicine, law, etc.).
	152	Public administration and defence.
	153	Entertainments and sport.
	154	Domestic service.
	155	Other personal services (hotels and restaurants, laundries, hairdressing, undertaking, etc.).
	156	Management of dwellings, etc.
	157	Management of overseas investments.

6.5. The 36 industries were reduced in Table 8 to 10 groups on the following basis:

Table 8.

	Industry Numbers in the List above
1. Agriculture and food	1, 26, 27
2. Coal and power	2, 6, 34
3. Building, building materials and timber	3, 4, 5, 28, 33
4. Chemicals and rubber	7, 8, 9, 31
5. Textiles and clothing	19–25
6. Paper, printing and miscellaneous	29, 30, 32
7. Metal making	10, 11
8. Engineering	12–17
9. Metal goods n.e.s.	18
10. Services	35, 36

7. *Appendix B: Statistical Methods*

7.1. The purpose of this appendix is to give a summary of the methods used in obtaining Table 5 (The Supply of Commodities) and Table 6 (The Distribution of Commodities), and estimates in Table 7 (Inter-Industry Relations) in so far as they are not derived from the data in Tables 5 and 6. Within the scope of the present paper obviously no detailed account of the sources and methods of estimation can be given.

The Supply of Commodities by Industry

7.2. The sources of data on the supply of commodities can be conveniently discussed under the headings (*a*) agriculture, etc., (*b*) industry, etc., (*c*) services, and (*d*) imports.

(a) *Agriculture, Fishing and Forestry*

7.3. The value of agricultural output by commodity is based on Ministry of Agriculture estimates for years ending in June. In the case of most crops, output in the agricultural year 1935–36 was

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taken as identical to output in the calendar year 1935, and for livestock produce outputs in 1935–36 and 1936–37 were averaged. As the result of experience gained during the war, the Ministry of Agriculture revised some of the estimates, partly in order to exclude marketing expenses incurred by farmers, but the revisions were carried back only to 1936–37. The estimates for 1935 were adjusted to make them comparable with the new set of official figures. Certain minor items were included in the output of agriculture which perhaps should not have been regarded as agricultural commodities.

7.4. The estimates regard the industry as if it consisted of one farm; that is, transactions between farms are excluded. Data for the quantities of important crops produced are, however, available.

7.5. The estimates of the output of allotments and back-yards, consisting of vegetables, potatoes, pigs, poultry and eggs, were based on Ministry of Agriculture estimates for years near 1935, with some adjustment in the valuation for 1935 prices. These estimates are necessarily inexact, but they cover a significant proportion of food production.

7.6. The weight and value of fish landed from British shipping vessels is also estimated by the Ministry of Agriculture. The estimates include sea fish only, and no data were available for fish caught in rivers and lakes, the value of which must be relatively small.

7.7. The National Home Grown Timber Council estimated the output of forestry for an "average" year near 1935, and it can be assumed that this estimate is approximately valid for 1935. Production was very small in relation to imports.

(b) *Mining, Manufacturing and Building*

7.8. The basic source of information for mining, manufacturing and building is the Fifth Census of Production, taken in respect of the year 1935. For the purposes of the present study this census is more complete than any of the previous ones. Owing to the outbreak of the war in 1939 the publication of the last volumes of the census was delayed and the analysis was not as complete as was intended. The results of the census of 1937, which contains certain additional information (especially on packing materials), are still not fully published, but whatever was available at the time the computations were made was taken into consideration in so far as it supplemented the information in the 1935 census. Similarly, the results of the 1946 partial census were studied in cases where they threw additional light on certain problems.

7.9. The Fifth Census of Production obtained returns from firms for accounting years ending between April 1st, 1935, and March 31st, 1936. It is thought that the average return coincides with the calendar year, but this is not necessarily true for each industry; in certain trades the accounting year ends on, for instance, March 31st, coinciding with the fiscal year. Problems arising out of this fact were ignored, but herein may lie the source of certain discrepancies between estimates of output for one industry and input for another, as regards both quantities and prices. Further, output and input as recorded in the census contains inventory profits or losses, which should have been eliminated; this affects both the value of output (obtained as sales plus increase in the value of stocks) and the value of input (purchases less increase in the value of stocks). As 1935 was a year of comparative stability problems arising from this source were also ignored, but again this reduces the accuracy of the estimates.

7.10. The census gives for each industry the output of "principal products" by commodity in terms of value and, if possible, in quantity, including identical commodities produced by industries where they are not "principal products". Further tabulations show the latter class, "principal products" produced by other industries, which is usually called "carry in"; and, conversely, the "other output" of the industry concerned, usually called "carry out". Hence "principal products" forming one commodity-class are equal to the output of the relevant industry ("gross output") plus "carry in", less "carry out". For the census as a whole, however, "carry out" exceeds "carry in" because some output is regarded as not forming the principal product of any industry, or may not have been sufficiently specified in the returns.

7.11. It was not always easy to find the industrial origin of "principal products" produced by "other" industries, or, conversely, the commodity breakdown of "other output", because of insufficient detail given in the census volumes. The information does, of course, exist, but to a large extent its publication is prevented by provisions for not disclosing information in respect of a small number of firms only. In consequence, Table 5 contains a number of estimates, ob-

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tained by collating the tabulations for different industries, whose accuracy might be checked against the official files.

7.12. The census excluded the output of establishments employing, during the year, on the average 10 persons or less, and estimates were made to correct for this omission, which was in most cases not great, but quite important in a few industries like bakeries, shoe-repairing, tailoring or building. The 1935 census did record the number of persons employed by such "small firms", or it gave an incomplete record from which estimates were made on the basis of the number of firms concerned. The value of output of "small firms" was, however, given in the 1924 census, and on that basis, comparing output per person employed in small establishments to that in large ones in the same industry, the value of output of "small firms" in 1935 was estimated. The commodity break-down of this output was estimated again with reference to 1924 data, an obviously unsatisfactory procedure, but one which cannot have an important influence on the results. It was found, for instance, that small grain mills tended to concentrate in 1924 on oat as against wheat products, and this was probably also true for 1935. In important cases, however, independent checks were made. For bakeries, for instance, the quantity of bread baked by *all* firms is recorded; for shoe repairs, utilization of material was considered; for building, expert studies were considered.

7.13. Output as officially recorded was in a number of industries deemed to be on an unsatisfactory definition and suitable adjustments were made, whilst the corresponding estimates for small firms were brought to the same definition. The following important instances may be mentioned:

(i) For textile finishing and packing only the value of work done was recorded. In so far as such work was done for manufacturing firms, it was included in the value of output of yarn, cloth or made-up goods, but in so far as merchants (who were not included in the census) bought the goods before finishing and packing, an addition had to be made to the census figures for yarn, cloth or made-up goods. These additions include not only the value of work done by the finishing and packing trades, but also the corresponding transport costs and merchants' other expenses and profits.

(ii) In certain industries, particularly cotton weaving, wool, silk, sacks, tanning, tailoring, fur and petroleum refining, a proportion of the output is recorded as work done on a commission basis, and in such cases only the value of work done and not the value of the commodities produced is included (although the quantities involved are sometimes available). Such work is partly for other manufacturing firms but largely for firms outside the scope of the census (merchants), and consequently estimates were made so as to include all output on a uniform basis, that is, by adding estimates for materials used (except ancillary materials already included in the value of work done), and the expenses and profits of merchants attributable to their functions as producers but not to their function as sellers. A typical case may be a department store, where only its workshop making up materials is within the scope of the census and only the value of work done is recorded; here an estimate was made of the value of output of the workshop as if it had been an independent manufacturing concern.

(iii) The printing and newspaper printing trades included publishers who did their printing work in the same establishment, but not publishers who subcontracted their printing or carried out printing in a different establishment, though belonging to the same firm. An addition was made therefore for the expenses and profits of the publishers so excluded, including in so far as necessary the cost of paper and of printing blocks, on the basis of estimates by Kaldor & Silverman (1948). H.M. Stationery Office also appears to fall into this category, and additions were made, on the basis of published accounts, for paper used and contract work given out.

(iv) In the fur trade the value of furs dyed or dressed for resale was excluded and only the value of work done was included, and this was corrected.

(v) Watches assembled by repair shops or dealers, and butter, cheese and other milk products made by distributing dairies, all of which were outside the scope of the census, were added based on estimates of materials used.

(vi) Although in general valuation includes excise duty, this was not the case of spirit distilling and here an addition was made. It is not stated clearly what the position of petroleum refining is, but it appears from the figures that output is valued excluding customs duty on crude oil.

(vii) The returns for the building industry are thought to exclude the profits of speculative

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builders and to under-estimate the value of work in progress. Further, the returns, especially for small firms and workers on own account, may have been defective. The estimates of Bowen & Ellis (1945) were used in conjunction with the census returns, particularly as regards the value of houses built.

(viii) For gas, electricity and water undertakings the value of construction work done on own account, or free of charge for customers, was recorded, but not included in the value of output. Here the construction departments of public utilities were taken separately from the producing departments, and it was assumed that the output of the former is sold to the latter. Similarly, in the returns of railway companies, tramways and the Post Office engineering department, construction work was separated from engineering work, involving certain additions to output in so far as, for instance, railway material made in the railway workshops was used by the construction department in the maintenance of the permanent way.

(c) *Services*

7.14. The output of transport, storage and communications was estimated at £517 million consisting of—

	£ *mn.*
Railways	159
Ocean shipping	133
less disbursements abroad	−55
Post Office	80
Other	200

Estimates for the railways (excluding ancillary activities) and the Post Office are based on officially published returns, adjusted for the calendar year. The estimate for shipping is based on a voluntary inquiry conducted by the industry in respect of 1936; the figures were adjusted for 1935 and a deduction made for disbursements abroad for stores, harbour dues, etc. The estimate for other transport is partly based on reliable sources (published returns for public passenger transport undertakings), and partly on rough guesses (for road transport of goods) based on employment, etc., data. Uncertainty is introduced in so far as it is not known how far the Census of Production covered the transport activity of road vehicles owned by manufacturers.

7.15. The estimate for the output of commerce and finance was £1,184 million consisting of the following:

	£ *mn.*
Distributive trades	939
Insurance	100
Banking, finance, estate, etc., agents	130
Advertising agents	15

The total of distributive margins is given in Table 6 as £1,170 million, and the way in which this figure was obtained will be given below. This figure, however, contains the contribution of inland freight transport (£190 million) and advertising (£15 million). Further, about £50 million is attributable to hotels and restaurants for the margin on food and drink served by them, and not to the distributive trades. On the other hand, an addition was made for margins on second-hand goods (estimated at £16 million, mainly motor cars and clothing) and for the expenses and profits of merchants (mainly in textiles), which, as explained in 7.13 (i) and (ii), were included in the value of commodities and not in distributive margins. The estimate for insurance covers the costs and profits of insurance companies, but not that part of the premiums paid which is returned to the insurer in payment for claims, and is based on the Board of Trade returns; for banking and finance the estimate is based mainly on employment statistics (which was related to employment in insurance), and for advertising agents on Kaldor & Silverman (1948).

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7.16. The output of other industries was estimated at £753 million consisting of—

	£ *mn.*
Public administration and defence	269
Enterternment and betting*	104
Domestic service	115
Professional and personal services, n.e.s.	265

* Including for the betting industry costs and profits only.

The estimate for public administration and defence is based on the accounts of government departments and local authorities, and represents wages and salaries paid (and social insurance costs) to public employees not classified under the other industries, plus depreciation not made good (£32 million). The estimate for the other industries is largely based on consumers' expenditure on services, adjusted for 1935 from the official estimates for 1938; additions were made for services (mainly professional) rendered to government and business, or those exported.

7.17. Further, an estimate was included for services derived from dwellings and buildings used by non-profit-making bodies (£412 million) which represents rents and rates, excluding water rates which were already included in the output of water undertakings; the estimate is derived from the corresponding official estimate for 1938. Finally income from overseas investments was included net of income from investments in Britain going overseas. The estimate of £184 million is based on Board of Trade balance of payments estimates, and excludes headquarters expenses (allowed for elsewhere) but includes income from government property.

(d) *Imports*

7.18. Total imports were taken into account, that is, re-exports were included, and these were classified in the same way as domestic output. Certain inconsistencies were found between the classification of imports and the input of industry, especially as regards wool, timber, non-ferrous and precious metals; it will be noted that the import classification was changed from time to time, as in 1937. In certain cases the quantities appeared consistent, but discrepancy was found in the values recorded; imported platinum, for instance, was owned abroad by the importing company and the return was nominal. It was also difficult to classify imports to which there was no corresponding domestic output as, in the case of partly processed commodities, it was uncertain whether they should be regarded as of agricultural or of industrial origin. A number of items, mainly parcel post, scrap and waste materials, remained unclassified.

7.19. To imports were added the corresponding import duties, which are classified in the appendix of the trade returns according to the classification of imports. Duties were taken net of drawbacks paid on exports except for the silk duty; here it was thought that the manufacturer of silk pays the duty, but in certain cases the manufacturer of finished products (hosiery or tailoring trades) receives the drawback.

7.20. The total of imports in Table 5 is shown as £787 million, as against £756 million of merchandise trade officially recorded. The difference consists of imports of second-hand ships (£2½ million) and of precious metals for industrial use, except in so far as already included in records of merchandise trade (which registered diamonds partially only and under-valued platinum).

7.21. Total imports as given in Table 7, at £802 million, include, in addition to the above, £2 million for travel in foreign ships, £6 million for government expenditure abroad, £5 million for film royalties and £2 million for remittances to missionaries; the balance of tourist trade was *nil*, and it was therefore ignored, whilst imports of certain other services were set against the corresponding exports.

The Distribution of Commodities by Industry

7.22. The distribution of commodities was estimated partly with reference to the nature of each commodity and partly with reference to whatever estimates of the input of industry or of final output were available. For each industry estimates were made for total commodity input, as distinct from value added, and each estimate was entered both against commodity supply and against the industry of destination. As far as possible individual commodities were taken

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into account, and in the more important cases the estimates extended to quantities as well as values. It will be noted that the nature of input depends not only on technical factors but also on the organization of industry; if the manufacture of cigarettes, for instance, is separated from departments of tobacco factories making cardboard boxes, then cardboard boxes will be an input of tobacco manufacturing; but in the case of integrated establishments sheets of cardboard will appear as input.

7.23. In the first place input or final output was recorded at "purchasers' value", and subsequently estimates were made for distributive margins relevant in each case in order to arrive at "sellers' value" since the supply of commodities was expressed in terms of the latter. For consumers' purchases the margins estimated by Jefferys (1950) for 1938 were accepted, bearing in mind that certain distribution costs were already included in "sellers' value". Adjustments were made for discounts on purchases by institutions and restaurants, and for the absence of margins on the consumption by producers of their own produce. For purchases by business distributive margins were estimated on the basis of scattered information, and they represent orders of magnitude rather than exact estimates. Care was taken to allow for transactions representing merely book-keeping entries between departments of the same firm located next to each other.

The following paragraphs contain notes on the estimates of input by industry and the estimates of final output:

(a) *Agriculture, Fishing and Forestry*

7.24. Estimates of the input of agriculture and of allotments are from the same source as estimates of output; the best information available refers to years later than 1935 and had to be adjusted. The estimates were checked for major items from the supply side. It was particularly difficult to distinguish the industrial origin of feeding-stuffs, as these are partly directly obtained from agriculture and partly pass through the processing industries. Input includes the distributive margin on sales between farms, which were not included in the output of agriculture. For fishing, estimates were available for fuel consumption, but other input could be estimated only with reference to data for foreign countries. The input of forestry was a small notional entry.

(b) *Mining, Manufacturing and Building*

7.25. The basic information on input is contained in the Census of Production, which gives for each trade the value of materials used, the amount paid for work given out and (but not always) excise duties paid. Estimates were made to allow for the input of small firms, and adjustments were made corresponding to the adjustments to output mentioned in 7.13 above. The distinction between "materials purchased" and "work given out" is not always obvious, especially in cases where manufacturers are also concerned with the installation of their product, and receipts for work carried out by one industry may not always correspond to the amount paid for work given out by another industry.

7.26. The extent to which details of materials used were given in the Census of 1935 varied greatly from industry to industry, depending partly on whether they were within the scope of the Import Duties Act inquiries. A large proportion of commodities is, however, specific, and the total supply available, is used by one industry; an example is raw tobacco. In other instances the input of a particular commodity was estimated from the value or weight of the corresponding output; the input of second-hand sacks into the canvas industry was, for example, estimated from the value of reconditioned sacks. In many industries particular attention had to be paid to its organization; if, for instance, the weight of raw materials used fell short of the weight of output, there was reason to assume that semi-finished products were also used as input. The census does give estimates of "duplication" within each trade (except in volume iv, which was published under abnormal conditions), but these had to be re-estimated as information by commodity was not given.

7.27. Relatively little use was made of information obtained by government departments as a result of war-time controls, and of information supplied by leading firms in industry. Greater use could be made of data supplied by business if the inquiry were repeated for a more recent year.

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(c) *Services*

7.28. Goods and services purchased by the distributive trades were estimated at £325 million. Of this amount the railways accounted for about £60 million, mostly for repairs and maintenance, and shipping over £20 million, excluding disbursements abroad. The rest is largely conjectural, and assumes goods and services purchased by the distributive industries to be 10–15 per cent. of output as here defined. This implies that of distributive margins about 30 per cent. was spent on goods and services, including payment for freight transport. Details were estimated for coal, petrol, ship and railway repairs, paper and printed material, and certain minor items such as milk bottles.

7.29. Goods and services purchased by other industries were estimated at £187 million, of which £95 million is accounted for by the maintenance of dwellings and buildings occupied by non-profit-making bodies, £7 million by film royalties and expenses on missionaries, which are payable abroad, and the rest is largely conjectural. It was assumed that 25 per cent. of the output of entertainment and betting, and 15 per cent. of professional and personal services are spent on goods and services, and that £10 million was the cost of management, insurance, etc., of dwellings. The whole output of public administration and of domestic service was equivalent to "value added".

7.30. Something has to be said about the distribution of the output of service industries. Of the output of the distributive industries (£1,701 million), £1,146 million was accounted for when distributive margins were estimated, including the margin on second-hand goods. Of the rest, £269 million represents direct consumption by households in the form of travel, communications, insurance and banking services, £101 million "invisible exports" in the form of shipping, insurance and banking services, and £185 million travel, communication, insurance, banking, etc., services to business and government; of the last, £6 million was the estimated share of government, £10 million was included in the cost of capital formation (mainly connected with the finance of house building), and of the residue about one-half was assumed to have been for the distributive industries, one-quarter for other service industries, and one-quarter for agriculture, mining, manufacturing and building, between which industries the relatively small figure was distributed in proportion to value added (excluding taxes).

7.31. The output of other service industries was largely directly consumed by households (£835 million) in the form of services rendered by dwellings, etc., entertainment, betting, domestic, hotel and restaurant, and other personal and professional services, by government (£269 million) corresponding to the output of public administration and defence, or exported (£187 million, net income from overseas investment including headquarters expenses). Of £56 million estimated professional services rendered to business and government, £15 million was the share of government, £10 million went to building (mainly architects' services), and the rest was distributed in the same way as the residue of distributive services.

7.32. £52 million was the estimated share of the Census of Production industries in services used by business (other than the distribution of goods), the most important being postal, insurance and banking services. It was assumed that these services were part of "net output", and not of "materials purchased" or "work given out".

7.33. An important item in the costs of business is expenditure on advertising, and for this it was possible to use the detailed estimates of Kaldor & Silverman (1948). They put total advertising expenditure, which was carefully defined, at £83·8 million. Of this amount £6 million represents the cost of advertising departments of large firms, mainly salaries, and this item is automatically allowed for in the present estimates. Of the rest £19·4 million was spent on commodities produced by the printing trades, £4·2 million on manufactured stationery, £38·4 million on newspaper advertising, £1 million on film and radio advertising, and £15 million on advertising agents' commission connected with all this. Hence advertising expenditure appears as purchases of commodities produced by the printing, manufactured stationery, newspaper, and entertainments industries, with agents' commission as the "distributive margin". For the Census of Production industries it was evident that expenditure on newspaper, film and radio advertising was included in "net output", but it is not certain how far other advertising was included in "materials purchased". To a large extent such advertising is part of the commodities sold, e.g., packaging and literature accompanying goods, and must have been included in materials used, and only a small proportion was thought to have been included under "net output".

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(d) *Exports*

7.34. Exports of physical commodities were valued at £520 million as against £481 million, which was the official value of exports of merchandise. The difference consists of gold and silver bullion and coins produced by the British refining industry and not used by other industries; second-hand ships (£6½ million); and repairs to foreign ships and expenditure by them on bunkers, etc. (£6 million). Whether the output of the British gold and silver refining industry was actually exported or stocked in the country was ignored, since in either case foreign assets increased and the simplest way of representing this was to include all in exports. "Invisible" exports were described elsewhere.

7.35. The classification of exports raised similar problems to that of imports. The industrial origin of some £14½ million of exports could not be found; most of this consists of parcel post, although exports of lace, books and newspapers through parcel post were accounted for.

(e) *Government Consumption*

7.36. The larger part of government consumption, £298 million, consists of "other services" including those imported, and was described elsewhere; £54 million is the contribution of the building industry and represents the maintenance of roads and public buildings; and £99 million consists of purchases of goods. These last were estimated from the accounts of the central government and a sample of local authorities. The identification of particular commodities purchased is surprisingly difficult. Care had to be taken to exclude commodities which were part of personal consumption, e.g., food consumed by the armed forces, and commodities which were already accounted for as the input of government industrial establishments. The government was taken to purchase, not steel, etc., but finished warships from naval dockyards. It was, however, exceedingly arduous to reconcile the accounts of trading departments (such as H.M. Stationery Office or Admiralty Dockyards) with the corresponding census of production returns. Of goods purchased by the government more than half was for the armed forces; with the exception of armaments, only a very small proportion of the output of manufacturing was used by the government.

(f) *Personal Consumption, Capital Formation, Stocks and Residues*

7.37. With minor exceptions, personal consumption and capital formation were estimated as residual items. Commodities were identified as consumption or capital goods, and their entire remaining supply, after deducting purchases by industry and government, and exports, was entered into either consumption or capital formation; the residual supply of intermediate goods was entered into "stocks and errors". In a few cases only, mainly taxed commodities, grains and coal, were independent estimates of stock change available.

7.38. In the case of a number of consumption goods, such as alcoholic drinks, small deductions were made for purchases by business. Where a commodity is generally used, such as water or fuel, special studies are required and, in the case of coal, coke, gas and electricity, Mr. J. R. N. Stone kindly permitted reference to his provisional estimates. For a number of commodities—notably alcoholic drinks, tobacco, soap, books and newspapers—various independent estimates of consumer purchases exist but these had to be converted into "sellers' value". Difficulty is experienced with finished commodities, such as typewriters, which are bought by business and consumers alike. In an exhaustive inquiry such as this, it is also found that consumers purchase small quantities of commodities which are predominantly not consumption goods, such as bricks, cement, ships or aircraft.

7.39. The statistical problems in estimating capital formation are not easy to overcome: parts of machinery, for instance, may be used as input of finished machinery, or bought by industry as replacement, or bought to be assembled by the purchaser, or sold jointly with finished machinery. (In the Census of Production it is not clear, for example, whether the value of typewriters includes the value of covers and accessories.) It is particularly difficult to allocate "finished" commodities, such as electric motors and pumps, which may be part of another machine. In building work sub-contracting creates difficult statistical problems, especially sub-contracting by non-building firms. A lift may be installed in a house by the builder, by the manufacturer acting as sub-contractor, or by the owner. In the first case the lift is sold to the building industry, in the second

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case both the lift and the cost of installation are sold to the building industry, and in the third the value of the lift and the cost of installation are additional to the value of the building.

8. *Appendix C: National Income Components*

8.1. A comparison is made here between the estimates made in the present study (Table 7) and those in the White Paper on national income (Cmd. 8203, 1951), in which the earliest year is 1938, and with the Board of Trade balance of payments estimate for 1935.

(a) *Personal Consumption*

8.2. The estimate of personal consumption in Table 7 is not directly comparable with that in Cmd. 8203, p. 24, because of differences in the principle of classification. The present estimates for 1935 arranged in the form of the official estimates are the following, compared with the estimates for 1938 (in £ mn.):

	1935	*1938*
Food	1,053	1,305
Alcoholic drink	229	285
Tobacco	153	177
Rent, rates and water charges	431	491
Fuel and light	137	197
Durable household goods	237	234
Other household goods	38	54
Clothing	422	446
Books, newspapers and magazines	72	64
Private motoring	124	127
Travel	150	163
Communication services	25	29
Entertainments	58	64
Domestic service	110	121
Other services	358	393
Other goods	191	177
Income in kind of the Armed Forces	..*	17
Tourist expenditure (net)	—	−9
Total	3,788	4,335

* Included in other items.

8.3. Although food consumption in 1938 was independently estimated, the estimates for 1935 and 1938 are surprisingly consistent in relation to movements in the index of retail sales. Durable household goods include domestic cookers and heaters, whether bought by consumers outright or on hire, since otherwise equipment on hire ought to be included in capital formation; in contrast, "other services" in the official estimates include the rental of such equipment. For books the 1935 estimate appears to be high, probably because a fuller allowance was made for printed music, bookbinding and similar work. The 1938 estimate for goods other than food, drink, tobacco and a few other commodities are based on the 1935 census of production, and hence are not independent from the present estimates. Nevertheless a number of minor discrepancies can be found, notably a fuller account of "other goods" in the present estimates. On the other hand, the 1935 estimates for most services are derived from the 1938 figures.

(b) *Government Consumption*

8.4. For purposes of estimating government consumption, the accounts of government were analysed distinguishing expenditure of various types in the same way as in Tables 20, 22 and 24

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of Cmd. 8203. Current expenditure on goods and services in 1935 and the corresponding figures for 1938 were the following (in £ mn.):

	1935	*1938*
Central government:		
Civilian	55	(92)
Military	130	(341)
Total	185	433
Local government	231	272
Social insurance funds	25	26
Total	441	731

The bulk of the increase between 1935 and 1938 was due to military expenditure, and also to civilian defence expenditure.

8.5. The official definition of current public expenditure on goods and services is, however, not satisfactory for purposes of analysis. Certain services provided by the government (such as education or hospitals) were partly privately financed by fees, etc., and the above estimates refer to net expenditure. On the other hand, the above figures include the government's share in the finance of services which are largely privately financed, and which are produced by persons not classified in public administration and defence; examples are grants to various societies and institutions, and these could more conveniently be regarded as subsidies. Actual government consumption is estimated at £10 million more than shown above, that is, at £451 million.

8.6. Government consumption was broken down in the following way, distinguishing goods purchased, services purchased, depreciation and maintenance, "invisible imports", and income payments, including social insurance contributions by the government as employer (in £ mn.):

	Goods	*Services*	*Depreciation and Maintenance*	*Imports*	*Income Payments*	*Total*
Central government:						
Civilian	1	3	4	2	40	50
Military	51	6	6	4	63	130
Local government	44	3	76	—	123	246
Social insurance funds	3	9	—	—	13	25
Total	99	21	86	6	239	451

(c) *Capital Formation*

8.7. The definition of gross fixed capital formation differs in one important respect from the latest official version: repair and maintenance work on dwellings, etc., on the permanent way of the railways and on roads and public buildings is excluded. The total for 1935 on the official definition would be £180 million more, that is, £693 million, as against about £820 million in 1938. Depreciation allowances in 1938 came to £457 million, and the corresponding figure for 1935 would be about £388 million; on the definition used here this would be reduced to about £208 million.

8.8. It is not possible to compare the present estimate with the 1938 estimate in any detail, since the official figure was to some extent arrived at as a residue. It should be stated, however, that the estimates given here include changes in the value of work in progress in the engineering industries where this was recorded in the census of production, and in the building industry where valuation is on the basis of work done; they include amounts received by the engineering industry for installing machinery; they also include capital goods produced by sundry trades, such as wooden sheds (made by manufacturers of wood) or vats (metal goods n.e.s.); but a deduction is made for second-hand machinery sold to be reconditioned or exported and for scrap metal arising from "capital scrap" on the assumption that depreciation allowances are net of such deductions.

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(d) *The Balance of Payments*

8.9. The balance of payments was estimated by the Board of Trade as £32 million and here as £6 million. Here trade in silver bullion and coin was ignored (+£14 million), and also immigrants' capital (estimated at £10 million), since the latter is already accounted for by domestic capital formation. Imports were increased to the extent that diamonds and platinum were underestimated, and gold and silver consumed by British industry were also allowed for, partly offset by receipt for refining on foreign account. For tourist traffic, diplomatic missions, insurance, commissions, and income from overseas, the net balance was entered, but otherwise exports and imports were taken on a gross basis.

(e) *Indirect Taxes and Subsidies*

8.10. Indirect taxes and subsidies were estimated the same way as in Cmd. 8203 except that employers' contribution to social insurance was included in taxes; wheat quota receipts were included in taxes and payments in subsidies. For reasons given in 8.5 above, however, fees amounting to £15 million were added to indirect taxes, making the total £629 million, and subsidies were increased by £5 million to £42 million.

8.11. Taxes paid by the distributive industries include a share of motor vehicle duties, stamp duties on financial transactions, and the Post Office surplus. Taxes paid by other service industries include certain licence fees, the entertainments duty, wireless licences, certain stamp duties, and rates on dwellings. Taxes paid out of personal consumption are confined to customs duties on consumption goods, certain licence fees, a share in motor vehicle duties, plus fees of £15 million mentioned above.

8.12. Of subsidies £10 million was for agriculture, £2 million for food processing (beet sugar), £3 million for the distributive industries (tramp shipping and other transport), and the rest for other service industries (mainly on housing).

(f) *Change in Stocks*

8.13. The change in stocks (plus any residual error) is the difference between the column and row totals for "unallocated" items and comes to £55 million. This is very close to the estimate of £51 million which is derived from balance-sheets (Barna, 1942).

(g) *National Income*

8.14. On the basis of the above estimates, net national income at factor cost (excluding employers' contribution to social insurance) came to £4,018 million in 1935, as against £4,652 million in 1938. The movement of the figure from one year to another is for practical purposes identical with that estimated by Stone (1945).

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DISCUSSION ON DR. BARNA'S PAPER

MR. STONE: It gives me great pleasure to have this opportunity of congratulating Dr. Barna on his excellent paper. A proper treatment of the important subject of inter-industry relationships in this country is timely and this has now been given. Dr. Barna has dealt not only with many interesting theoretical aspects of the subject, but has also carried out the difficult task of estimating the elements in an inter-industry transaction matrix for 1935. This shows how much can be achieved even with the data available before the war, and gives encouragement to those who wish to see this branch of economic statistics more fully developed in this country. I imagine that all who have followed the paper will wish to know whether the author has taken any steps to invert his matrix, and whether he is planning any further analytical work on this basis. Perhaps Dr. Barna will say a few words on this subject in his reply.

The author has said in paragraph 1.2 that econometric research has in the past been largely either partial or aggregative. As examples of these two approaches he has cited demand and supply analysis for individual commodities and the analysis of national income and expenditure, which includes the work on economic models of such writers as Tinbergen and Klein. I think that the study of inter-industry relationships must also be considered as a form of aggregative analysis, although the kind of aggregation is different from the one adopted in fiscal policy models.

Both types of model can readily be placed in the same conceptual framework. For simplicity I propose to confine myself to models which I have elsewhere called simple transaction models, that is to say models in which the variables are transactions and the relationships are either accounting identities or response patterns in which it is assumed that the outgoings from any account depend simply on the total of incomings receivable by that account.

The transactions of an economic system can be represented by the elements of a square matrix **W** in the columns of which there appear outgoings and in the rows of which there appear incomings. The total incomings of each account, denoted by the vector **v**, are obtained by summing the elements of **W** by rows, that is to say, by postmultiplying **W** by the unit vector $\mathbf{1}, \equiv \{1, \ . \ . \ . \ 1\}$. The response relationship will express the elements of **W** in terms of the elements of **v**. If nothing more complicated is considered than a dynamic linear system of responses in which all time-lags are multiples of a unit time-lag then the response relationships can be denoted by

$$\mathbf{W} = \mathbf{A} + (\mathbf{BE})\ \hat{\mathbf{v}},$$

where $\hat{\mathbf{v}}$ is a diagonal matrix with the elements of **v** in the leading diagonal, where E^0 is a lag operator, and where **A** and **BE** are square matrices respectively of injections and responses. Dr. Barna's model is of the type just described with $\mathbf{A} \equiv \mathbf{O}$ the null matrix, $0 \equiv o$ in all cases so that no time-lags are introduced, **W** restricted to contain only transactions in goods and services, and with the accounts consolidated effectively over forms of activity as opposed to sectors of the economy. The simple Keynesian transaction model, the prototype of the aggregative models that Dr. Barna has mentioned, is similar in form to the above except that the restrictions on **A** and **W** are relaxed and the consolidation of the accounts is over sectors and not over forms of

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activity. Since in general there are many sectors and few forms of activity, it can be claimed, as is done by Dr. Barna, that the fiscal policy model is more aggregated than the inter-industry model.

I think it evident that each type of model has its uses and that a combination of the two is in principle desirable. From the point of view of use it seems that the Keynesian type of model should be useful in under-employment situations in which the government can set itself the task of raising the level of activity and employment without much regard to the composition of the basket of commodities produced. On the other hand in an inflationary situation, and particularly in one where rearmament necessitates certain types of output, there is less need to worry about fiscal and monetary devices and more need to consider what baskets of commodities can be produced in the existing situation. Under inflationary conditions the constraints on the economic system come mainly from the side of supply rather than demand, and it is because at present this and most other countries are in a condition of inflation that I spoke earlier of the timeliness of Dr. Barna's contribution.

My final comment relates to partial equilibrium analysis. Dr. Barna has said, and I agree with him, that a real difficulty in applications arises from the large number of influences that one would like to take account of in the regression equations. I think, however, that by various devices considerable reductions can be effected. In my own recent work on demand analysis I wished to measure the responses to some six to eight influences. I did this by using both budget data and time series in such a way that neither equation contained more than three determining variables. From the budget data I obtained estimates of the responses to income, family size and social or occupational class. It appeared to be appropriate to treat consumption and income per unit consumer as variables, and so from time series consumption per unit consumer, corrected for the effect of variations in income per unit consumer, could be expressed in terms of prices and time as a carrier for slowly changing influences associated with tastes and habits. But experience shows that it is appropriate to assume that the proportionality condition is satisfied, so that the number of price variables can be reduced by one, and it also appears that a first-difference transformation of the variables effectively reduces serial correlation in the observed residuals with the result that time does not have to be introduced into the equations, but a measure, though admittedly rather a rough one, of its residual influence can nevertheless be obtained. I found it possible by these means to estimate a large number of cross-elasticities of demand which I could not have done from a straight-forward analysis of time series.

In conclusion I wish to express again my admiration for the paper and to propose a hearty vote of thanks to Dr. Barna.

Mr. STAFFORD: It gives me great pleasure to second this vote of thanks and to express my personal appreciation of the paper. The amount of work which has gone into the tables so modestly appended has been considerable, as many Government statisticians know who have done their best to help Dr. Barna in this work. All statisticians, and especially official ones, are much indebted to Dr. Barna for showing what can be done in this field with pre-war data which were by no means well adapted for this kind of employment.

We are now considering what can be done with the post-war data, and I hope academic people and Government statisticians will be able to carry on where Dr. Barna has left off. Many of the difficulties which Dr. Barna has experienced will be eased by the additional information now available for the post-war years. The 1948 census gives a good deal more information about the inputs of individual industries than was available in 1935. We have a post-war census of distribution to assist us, and we have considerable information about the analysis of channels of sales. That, together with all the information now available outside the census of production, will, I think, help to make this kind of work more precise.

I think there is a very real theoretical difficulty in the treatment of depreciation for wear and tear. Depreciation is not normally a physical thing; it is essentially a financial concept. In financial terms, the making good of depreciation can be distinguished from net investment. But in real terms, there is, I think, no dividing line which can be drawn between the two flows of goods.

Another thing that strikes one forcibly is that the practical usefulness of this kind of work is very much increased if one can increase the number of cells in the table. In the author's model for 1935 he has managed to reduce very strikingly the carry-ins and outs from industries. He has done this by selecting some thirty categories within the field of the census of production. But this can only be done at the expense of hiding a good deal of usable detail, both of output and input. If the exercise is for practical purposes, it is undoubtedly an advantage to be able, for example, to trace the consequences of an increase in the output of some more specialized goods, and, in preparation, increase the number of cells under study. In doing this, however, a real difficulty is encountered. In the total output of makers of specialized goods there is frequently

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a high proportion of other goods, and the inputs which can be ascertained for the group cannot be split between that appropriate to the specialized goods, on the one hand, and to other goods on the other. The prospect of attempting to attribute inputs is disturbing to the official statistician.

I should like to repeat how interesting I have found Dr. Barna's work and how grateful we are to him.

The vote of thanks was put to the meeting and carried unanimously.

Mr. BURGESS CAMERON said that he had been very much impressed by Dr. Barna's labours in building up the chessboard table of industry interdependence. As he understood it, work of this nature fell into two parts. The first, although arduous, was by nature purely descriptive: a development of social accounting which set out the money-flows between industries, the transactions matrix. The second was analytical, and involved the use of a clearly articulated theory of general interdependence for which the transactions matrix might supply some or all of the figures required.

Hitherto the only theory of general interdependence which had been used was the special equilibrium version of Professor Leontief. It appeared that Dr. Barna was not definitely committed to the Leontief model although he envisaged its application. Accordingly it was worth while to observe that the Leontief model was but *one* form in which the theory of general interdependence might be applied. In particular the Leontief model rested on a number of important assumptions which he wished to mention. His main plea with regard to these assumptions was that they should be tested *before* the model was applied.

The major assumptions of the Leontief model could be grouped under three heads. The *first* referred to the treatment of foreign trade and of investment. The model envisaged a "foreign trade industry" having exports as its inputs and imports as its homogeneous output absorbed by industry in fixed proportions with home-produced commodities. Of the several possible methods of handling an open system this seemed the most likely to mislead. A preferable alternative was that the system be so constructed that the quantities of each export and the quantities (but preferably the prices) of each import were fed in as predetermined parameters. Turning to investment, Leontief assumed that the investment process affected the input of all the factors in the same degree. This implied that increased investment in, say, flour-milling resulted *ipso facto* in an increased input of wheat. To avoid this unrealistic procedure, the system could again be so constructed that the demand for each investment good was fed in as a parameter. He added that the Governments of the United States, Canada and Australia did publish investment forecast statistics which were of use in this connection.

The speaker then turned to the *second* group of assumptions of the Leontief model. A productive system might be conveniently regarded as comprising three parts: the scarce resources; the technology and competitive structure of the industries using those resources; the tastes and demand of consumers for final commodities. With regard to each of these parts Leontief made a major assumption. Firstly, the sole scarce resource was labour. This restriction to a single resource was not necessary to the model, as Dr. Barna had pointed out, and it seriously limited its usefulness. Secondly, as to consumer-demand, it had been assumed that price elasticities of demand were zero and income elasticities unity. In later work Leontief had dropped this in favour of a fixed bill of goods. This changed procedure was unexceptionable, but so long as the use of consumption functions was avoided, practical analysis was largely limited to examining the consistency of the fixed demands made upon the system of production. Thirdly, as to technology, it had been assumed that the structure of production was perfectly rigid, i.e., production functions were characterized by fixed input coefficients.

From a scientific viewpoint he suggested that the procedure which had been followed, namely of using the fixed input coefficients assumption without giving it a thorough test, was certainly undesirable. The speaker had been carrying out a practical investigation of some manufacturing industries which, though by no means conclusive, gave some support to the hypothesis that in the short run, price substitution was much less important than had been often supposed. Observed labour input coefficients however were definitely not characteristically constant. On the contrary in almost all industries analysed there was a marked general tendency to maintain a fixed reserve of labour. The employment-output relation might still be linear, but the Leontief assumption did not fit these cases sufficiently closely to be useful.

Finally, the *third* problem was that of the permissible degree of aggregation. The present speaker was not nearly as sanguine as Dr. Barna on this matter. The Leontief model was likely to stand or fall on the aggregation problem—if only because the method of relying on value data (the transactions matrix) broke down if aggregation were to invalidate the assumption of fixed input coefficients for the aggregated industries.

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Dr. R. M. Goodwin said that after reading Dr. Barna's paper he had the impression that nowhere else could be found an introduction to the subject expressed with comparable lucidity and candour. Commonly input-output analysis got uncritical enthusiasm or blank hostility. By contrast Dr. Barna gave them no great comfort about the soundness of the empirical foundations, and yet he showed why they must get on with it.

If they stepped back and took a long-run view of the question, he thought they could see why. Economic analysis provided a good example of the familiar proposition that the English mind tended to be concrete and empirical by contrast with the more rational and systematic continental approach. Thus it was in this country that was found the rich elaboration of partial equilibrium theory, and on the Continent the development of the idea of interdependence and the grandiose conceptions of general equilibrium. His feeling was that British methods, precisely because of a certain narrowness, had been the more fruitful But he would also like to suggest that this was no longer true and that further progress required general interdependence analysis. Keynes had convinced them of the inadequacy of partial equilibrium theory but the aggregative constructs that he left them were rather unsatisfactory in theory, and, more particularly, were inadequate for the applied economist or civil servant, who must find quantitative answers referring to specific parts of the economy.

What they wanted, and needed, was the behaviour of the whole economy as it arose from the interdependent motions of the parts. As any student of mechanics could affirm, such a general problem was insoluble, and it should perhaps be given up for lost. Yet, regarded simply as the best working approximation, Professor Leontief's method, which had the, perhaps, unique quality of being at the same time an affront to the intelligence of both the empiricist and the theorist, had a great deal to recommend it. There was no escape by training their microscope more sharply on the single parts of the economy; these were too liable to be swept right out of their field of vision. On the other hand if they looked honestly through the Keynesian telescope they saw more of a stellar cloud than any neat solar system. By a delicate and informed blending of aggregation and disaggregation it was possible that they would get certainly not the whole truth, but more of it than in any other way. For this reason he was particularly interested in Dr. Barna's statement that it was not necessarily true that the finer the subdivisions the better the results. They might attempt to find an optimum subdivision in terms of economic criteria, not of the categories of official statistics nor of the power of available computing machines.

The development of these statistical input-output models was costly and it was experimental. They were not sure that they would get good answers to the many different problems that could be put to the models, but surely it was a risk worth taking. His own interest in the subject came from the desire to apply some of the electric circuit theory to economics. Unfortunately, they did not know for economics what they knew for electricity, namely, that observed values held, to a good approximation, linearly over a wide range.

Both because of the experimental nature of the model and the great cost, the developmental work should be the concern of the Government; and rightly so, since the Government was the principal beneficiary. Thus, for example, it was difficult to see any other way of discovering the consequences of alternative large rearmament programmes, as to magnitude, composition and timing. The United States Government was spending a large sum of money on American input-output models. Surely the splendid work begun by Dr. Barna should be similarly carried on here. It was not only the cost, but the Government alone had the power to see that the appropriate statistics should be collected, and that there should be continuing correction of the coefficients in the light of changes not explained by the model.

Dr. Barna, in a preliminary reply to Mr. Stone's question, said that the matrix had not yet been inverted, but provisional arrangements had been made to do this.

Mr. Cameron had warned him against various dangers of the Leontief model. He had not used the term "Leontief model" in this paper, because there were several Leontief models, and the model which Mr. Cameron described was a rather theoretical one.

Dr. Barna subsequently wrote as follows:

Mr. Stone is perfectly right in stressing that the different models have their application in different circumstances and that they can all be regarded as special cases of a general model. He uses the term "activity", however, in a different sense from that used in my paper, in so far as he means by activity, consumption, investment, etc. He says (in my own terminology) that my model consolidates all final output into one category but distinguishes activities, that is, industries; on the other hand, the Keynesian model does not distinguish industries but differentiates final output into personal consumption, capital formation, etc. Put in another way, the

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Keynesian model is concerned with the determination of the total volume of final output but not with its composition according to industrial origin, whilst my model is concerned with the structure of industry but not with the aggregate volume of production. It is easy to see that the two models are complementary and can be used in conjunction with each other.

I did not here consider general models at all since I was concerned only with models which can be empirically applied, and I feel that this may not be the case with Mr. Stone's model. Moreover, in so far as one would proceed further from the model presented in my paper, I believe there are two useful directions in which generalization can be made. One of the extensions involves the introduction of capital as input and presents the model in a dynamic form; work along these lines is already in progress at Harvard University under the direction of Professor Leontief. Developments in another direction lead to the introduction of a number of alternative methods producing a given commodity, between which methods choice is possible; this work is carried out mainly at the Cowles Commission in Chicago.* This latter generalization makes use of a non-square matrix of input-output coefficients, and in this sense it is more general than Mr. Stone's square matrix.

Mr. Stafford is correct in mentioning the difficulties attached to the concept of depreciation. In any economic model concerned with long-term development it is nevertheless essential to take account of the physical counterpart of depreciation. Although I am fully aware of the theoretical difficulties, the actual obstacles with which I was confronted, and which I explained in my paragraph 4.5, were statistical, caused by an important lack of data in this field in the United Kingdom.

I do not fully agree with Mr. Stafford in stressing the usefulness of increasing the number of industries to be distinguished. It is possible that one ought to have more industries than are distinguished in my paper but, as I argued, at some stage an optimum number is reached, and this limit is set by theoretical and not by statistical considerations. The important fact to bear in mind is that a model dealing with the interdependence of the economy as a whole is mainly intended to serve the purposes of central economic policy, and that problems which are more in the nature of departmental problems should not be tackled within the framework of a general model, but through extensions of this general model by special studies relating to particular industries.

Mr. Cameron's comments relate almost entirely to the model in the earliest works of Professor Leontief, which we now call a closed model as it had no final output or primary input. In fact, Professor Leontief used an open model in later work, and my paper throughout deals with an open model, to which Mr. Cameron's comments may not apply. I fully sympathize with him, however, in believing that production functions can be determined only by empirical investigations, and I suppose the same applies to the permissible degree of aggregation, which is an interrelated problem. His example of labour input coefficients no doubt referred to short-term variations. I should mention that computations are still simple if the input-output relationships are linear though the input coefficients are not constant.

I should like to thank all speakers who contributed to the discussion for their encouraging remarks, and particularly Dr. Goodwin for emphasizing the interest which the Government ought to have in research of this nature.

As a result of the ballot taken during the meeting the candidates named below were elected Fellows of the Society:

Donald Kenneth Ashpole.
Anthony Stafford Beer.
Norman Benz.
Paul H. Berent.
John Charles Beresford.
Thomas W. H. Buckley.
Eric Stanley Carden.
Cyril Tetlow Daltry.
Norman Reginald Gatenby.
Goh Keng Swee.
John Randal Haigh.
John Donald Hampton.
Denis Alfred Hansman.
Charles Lloyd Harwood.
Maurice William Jones.
Montague Edward Joseph.
Geoffrey Lee.
Thomas Rae Manley.
Yvonne Manley.
Michael Egerton Martin.
Walter Edwin Mason.
Alan James Mayne.
Peter Gerald Moore.
Graham John Morris.
Kenneth Glover Murden.
John Denniss Neil.
Richard Michael Robbins.
Ulric Max Spencer.
Grace Margaret Swanson.
Vensi Detaram Thawani.
George Donald Warrington.
Sheila Patricia Waterman.
Arthur Thomas Wilford.

* Cf. especially the book edited by Koopmans, given among my references.

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Index Numbers of the Real Product of the United Kingdom

By C. F. Carter

In a paper (Reddaway, 1950) read before the Society on May 17th, 1950, Mr. W. B. Reddaway gave the first results of some researches into the movements of the real product of the United Kingdom, conducted by him at Cambridge jointly with Mr. J. R. N. Stone and myself. In replying to the discussion on this paper Mr. Reddaway announced that "it was the team's intention to publish a much more detailed account when energy and publisher's priorities permitted". The present Note is submitted to redeem this promise and also to communicate the results of substantial additional work. This work has been undertaken at the Department of Applied Economics, Cambridge, under my direction, but the immense burden of detailed calculation has been carried by the unfailing competence of Mr. A. A. Adams of the Department, and of Miss S. Y. Mallett, Assistant in Statistical Research in the University of Cambridge. Our debt to many people, inside and outside the Government service, for the information and help which they have so readily supplied has grown yet further; I can recollect no occasion on which the assistance we asked for has been denied, and the whole project has been a most happy instance of co-operation between statisticians.

The column headed "1948", in the table below, gives for each industry our estimate of the value added by that industry in 1948 to the goods and services which it bought from other industries or from abroad. These estimates, which are the "weights" of our index, have now been computed before deduction of provision for depreciation. We have tried to avoid the use of the terms "gross" and "net", which are liable to misunderstanding; for the weights are not far different from either "net outputs", in the Census of Production sense, or "gross products" in the National Income White Paper sense.

No details are here submitted of the methods used in obtaining the weights, though we are, of course, prepared to give detailed information on request. Some of these methods are described in Mr. Reddaway's paper, but they have little permanent significance; in particular, further extensive revisions will become possible when the final results of the 1948 Census of Production are at last available, and the first results of a Census of Distribution will throw much light on dark places. The weights here given have been revised, using information available up to July, 1951, and they have been related to two frameworks. One of these is supplied, for the industrial sectors, by the preliminary results of the 1948 Census of Production, published in the *Board of Trade Journal* at various dates in 1950 and 1951. The other framework is Table 1 of the National Income White Paper (Central Statistical Office, 1951*a*) which divides the "gross domestic product" at factor cost between 14 sectors.

The weights, however, will not fit precisely into either of these frameworks. The main reason for this is our inability to keep exactly to the Standard Industrial Classification (Central Statistical Office, 1948). The changes made have been explained elsewhere (Reddaway, 1950, p. 441), and they are indicated wherever possible by appropriate transfer items, given in square brackets in the table below. Three call for special mention:

(i) Intermediate services to business, for which no ready indicator was to hand, have been consolidated with the businesses using them, and are reflected indirectly through the final output of those businesses. This applies both to services rendered for payment (e.g., accountancy) and to services given "free" by the State (e.g., Employment Exchanges).

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(ii) The weight for road haulage includes a part for C-licence vehicles, and this is, in effect, transferred from all the industries which own these vehicles.

(iii) The weight for building and civil engineering differs explicitly from the Standard Industrial Classification by including minor road maintenance by local authorities. It also includes maintenance and construction undertaken by the staffs of public utilities, which, in a Census of Production, would usually be classified on an "establishment" basis to the industry to which the utility belongs.

It will be remembered (Reddaway, 1950, p. 440) that our index numbers relate to establishments situated within the geographical boundaries of the United Kingdom, whatever their ownership, together with ships under the U.K. flag on the high seas, all ships trading in British coastal waters, British aircraft on international services, and diplomatic and military establishments abroad. The value added by head offices in the U.K. of firms operating overseas is included, but not the value added by the overseas operations. Foreign diplomatic and military establishments in the U.K. are omitted, but the operations of foreign firms in the U.K. are included. Unfortunately the National Income White Paper has now defined "gross domestic product" to include the earnings overseas of British firms in the oil and insurance industries (Central Statistical Office, 1951*a*, p. 53, note 15). On this definition the sum of national domestic products would exceed the world's product. We use the term "product of the United Kingdom" for the concept as we have defined it, and it follows, of course, that there will be some divergence between our weights and the "gross products" in Table 1 of the White Paper. Other divergences which will be noted are due to the fact that, in a few doubtful cases, we have seen reason to prefer our own estimates to the official ones.

The figures in the remaining columns, 1946–50, show our estimates of value added in those years at 1948 prices, when this value is assumed to vary in proportion to the movements of the indicator shown. Some of the indicators are from private sources, but the majority may be found in the usual books of reference, such as the *Annual Abstract of Statistics* (Central Statistical Office, 1951*b*). The use of the indicators involves various assumptions, in many cases (for instance) homogeneity of product and a constant relation between input and output; and it should also be noted in particular that the value added in an industry has often to be assumed to vary with the output of a *major* product, the output of subsidiary items being unknown. Care should be taken to avoid the idea that the value added is attributable solely to the product named in the indicator.

At the end of the main table the estimates for the various Orders are brought together, and expressed as index numbers with 1948 = 100; and below (in continuation of Reddaway, 1950, Tables 3 and 4, pp. 454–5) the estimate of the product of the United Kingdom is related to the Real National Income, and to the residue of that income after deducting "regrettable necessities". These "regrettable necessities" have now been redefined to include only the largest of the items of expenditure which do not appear to contribute to positive welfare, namely, the armed forces, munitions, civil defence and the cost of occupying Germany.

Some comments on the results obtained have been made elsewhere (Carter, 1951). The figures are given here as the raw material for further research; and, in order to facilitate their combination into new aggregates, two places of decimals have in general been carried. The second of these is certainly never significant, and it is seldom that much reliance can be placed on the first; in some sectors, of course, our estimates may easily be in error by millions or tens of millions of pounds. The whole work has been revised up to mid-July, 1951, but at that time many 1950 figures, and a few for 1949, were still unavailable; we have had recourse to various means of indirect estimation, and the results for 1950 must be regarded as highly provisional.

Attention is also drawn to the following two *notes:*

(a) For a few industries employment has been used as an indicator. In order to avoid a downward bias, a "productivity factor" has been applied, obtained from the relation between employment and product in the remainder of the index. This factor has sometimes been varied to take account of special information, but any conclusions about the relation between employment and product drawn from our estimates must be regarded as based on that part of the field which is *not* represented by employment indicators. The National Insurance Act causes a break in the continuity of employment series at mid-1948, which we have bridged as best we could.

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(b) Where the movement shown by an indicator is confidential we have suppressed the estimates, and such cases are indicated by the letter "c" (cf. for instance Order I). In order to prevent these estimates being deduced or closely estimated by subtraction, other figures have been suppressed as well; these are indicated by the letter "d". Other abbreviations used are: "Pr." for production, "Cons." for consumption, "Del." for deliveries.

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REAL PRODUCT, REAL NATIONAL INCOME, AND INCOME LESS DEFENCE EXPENDITURE

	(£*mn.*, 1948 *prices*)				
	1946	1947	1948	1949	1950
Real product of the U.K.	9,956	10,090	10,622	11,124	11,516
Adjustment for:					
Terms of trade*	+100	+9	0	−2	−146
Net income from abroad†	+70	−2	−1	+27	+65
Estimate of real national income including depreciation	10,126	10,097	10,621	11,149	11,435
"Regrettable necessities" (limited definition—defence and related expenditure only‡)	2,050	950	750	750	775
Real national income *less* regrettable necessities	8,076	9,147	9,871	10,399	10,660

* The difference between the exports of the year, revalued to 1948 prices in accordance with changes in *import* prices (to give the import-equivalent of the exports), and the same exports revalued at 1948 *export* prices. The overall indices of import and export average values have been used. The calculation is, of course, very approximate.

† From Cmd. 8203, revalued at 1948 import prices. Excludes (though it should include) earnings of oil and insurance companies from overseas operations.

‡ The additional items (e.g., tax collection) previously included are so small relative to defence expenditure, and the number of marginal items is so large, that it was thought simpler to limit this adjustment to defence, and the costs of occupying Germany. Sales of surplus stores are deducted from the gross expenditure. For details see below.

Regrettable Necessities (*limited definition*)

By financial years, £ mn.:	1946/7	1947/8	1948/9	1949/50	1950/1
Total cost, actual or estimated, including services rendered by other departments, and after deducting all appropriations in aid and receipts paid direct to the Exchequer, and excluding estimated cost of "civil" work:					
Armed Forces, Civil Defence, Ministry of Supply, Secret Service, Foreign Office (German section), National Service registration	1,594	791	748	788	863
Estimate of cost at 1948 prices**	1,832	824	748	758	792
	1946	1947	1948	1949	1950
Estimate of cost by calendar years (to nearest £25mn.)	2,050	950	750	750	775

** Deflated by weighted average of principal relevant price series.

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Order I.—Agriculture, Forestry, Fishing

Standard Industrial Classification (Minimum List)		*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)*				
Number	*Heading*			1946	1947	1948	1949	1950
1.	Agriculture and horticulture[1] (Also 240 (part) Dealers [+6·0], 260 (part) Ministry of Agriculture [+10·0], 279 (part) Vets [+4·0])	Agriculture and related activities	Net output at constant prices	c	c	c	c	c
		Total: 1[2]		c	c	c	c	c
2.	Forestry	Land planted—Forestry Commission	Acres G.B.	d	d	d	d	d
		Forest Area (*for* care of woodland)	Acres	d	d	d	d	d
		Hardwood	Pr. cu. ft.	d	d	d	d	d
		Pitwood and softwood	Pr. standards	d	d	d	d	d
		Total: 2		d	d	d	d	d
3.	Fishing	Landings of British taking:	Tons G.B.					
		Prime white fish		d	d	d	d	d
		Plaice and other flat fish		d	d	d	d	d
		Coarse round fish		d	d	d	d	d
		Cod		d	d	d	d	d
		Haddock		d	d	d	d	d
		Hake		d	d	d	d	d
		Whiting		d	d	d	d	d
		Herrings		d	d	d	d	d
		All other demersal and pelagic fish		d	d	d	d	d
		Imports from British Fisheries:						
		Whale oil, unrefined	Tons	d	d	d	d	d
		Other fish and marine animal oil, unrefined, including liver oil	,,	d	d	d	d	d
		Other products[3]	Value deflated	d	d	d	d	d
		Total: 3		d	d	d	d	d
Total—Agriculture, Forestry, Fishing				549·27	554·03	608·00	646·51	591·76

[1] Includes also related activities, such as livestock dealing, dealing in home-produced seeds, and the work of veterinary surgeons.

[2] See note (b).

[3] Deflated by assumed price series.

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ORDER II.—MINING AND QUARRYING

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
10.	Coalmining	Disposals in tons of:						
		Anthracite		8·18	7·55	7·20	7·75	8·34
		Bituminous—Large coal		122·30	123·13	125·60	126·90	125·64
		Unscreened		24·91	24·99	24·40	25·57	25·23
		Graded		62·85	60·90	72·40	76·86	78·80
		Slacks and smalls—wet		39·25	43·20	50·00	55·96	58·76
		dry		44·34	48·67	47·10	46·92	48·69
		Other		7·86	8·69	8·00	8·82	9·43
		Miners' coal		9·55	9·85	9·90	9·70	9·99
		Colliery consumption		16·55	17·08	17·40	16·65	16·65
		Residual[4]		−1·86	−0·07	1·50	−2·36	−5·48
		Total: 10		333·93	343·99	363·50	372·77	376·05
11.	Iron ore mining and quarrying	Iron ore	Pr. tons	4·09	3·65	4·40	4·50	4·35
19 (1).	Other metalliferous mining and quarrying							
		Total: 11 + 19 (1)		4·09	3·65	4·40	4·50	4·35
12.	Stone quarrying and mining	Production of:	Tons					
14.	Clay, sand, gravel and chalk pits	Igneous rocks		4·61	5·09	5·30	5·62	5·82
19 (4).	Other non-metalliferous mining and quarrying	Limestone		6·18	6·39	7·70	8·11	8·45
		Sandstone		1·25	1·36	1·50	1·67	1·80
		Gravel and sand		6·07	6·83	7·60	8·34	8·97
		Clay, shale, etc.		1·64	2·30	2·60	2·93	3·14
		Fireclay		1·36	1·57	1·50	1·55	1·51
		China clay		1·05	1·32	1·70	1·63	1·75
		Chalk		0·95	1·06	1·20	1·43	1·56
		Silica stone and ganister		0·99	0·98	0·80	0·66	0·59
		Gypsum		1·23	1·27	1·60	1·62	1·68
		Total: 12 + 14 + 19 (4)		25·33	28·17	31·50	33·56	35·27
13.	Slate quarrying and mining	Roofing slate	Pr. squares	1·94	1·77	2·30	2·18	2·10
		Total: 13		1·94	1·77	2·30	2·18	2·10

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ORDER II.—MINING AND QUARRYING (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
14.	Clay, sand, gravel and chalk pits	See 12						
19 (1).	Other metalliferous mining and quarrying	See 11						
19 (2).	Salt mines, brine pits, salt works	Salt production from brine	Pr. tons	2·52	2·45	2·60	2·52	2·55
19 (3).	Oil shale mines, oil wells	Crude oil and shale oil	Pr. tons	1·31	1·13	1·20	1·24	1·23
		Total: 19 (2) + 19 (3)		3·83	3·58	3·80	3·76	3·78
19 (4).	Other non-metalliferous mining and quarrying	See 12						
	Total—Mining and Quarrying			369·12	381·16	405·50	416·77	421·55

[4] Residual represents production of saleable coal less items listed.

ORDER III.—TREATMENT OF NON-METALLIFEROUS MINING PRODUCTS OTHER THAN COAL

20.	Bricks and fireclay goods	Building bricks	Pr. number	11·77	15·48	15·70	17·84	20·19
		Roofing tiles (clay)	Pr. squares	2·21	3·37	3·60	3·22	2·98
		Flooring tiles (clay)	G.B. Pr. sq. yds.	0·59	0·98	1·20	1·06	1·07
		Refractories:						
		Firebricks: $\leqslant$ 3 in.	Pr. tons	1·86	1·92	2·30	2·48	2·45
		$>$ 3 in.	,,	1·56	1·66	1·90	2·03	2·09
		Silica bricks: $\leqslant$ 3 in.	,,	1·17	1·10	1·30	1·31	1·13
		$>$ 3 in.	,,	0·93	0·95	1·20	1·22	1·24
		Chrome and magnesite bricks	,,	2·17	2·33	2·60	2·63	2·47
		Other refractories	,,	0·84	0·83	1·00	1·11	1·10
		Stoneware pipes	G.B. ,,	2·43	2·97	3·10	3·09	3·15
		Fireclay sinks	G.B. ,,	1·16	1·41	1·60	1·59	1·55
		Total: 20		26·69	33·00	35·50	37·58	39·42
21.	China and earthenware (including glazed tiles)	Lavatory basins	G.B. Pr. numbers	1·50	2·04	2·20	2·27	2·50
		Glazed wall and ceramic floor tiles	G.B. Pr. sq. yds.	3·13	3·77	5·00	5·26	5·24

ORDER III.—TREATMENT OF NON-METALLIFEROUS MINING PRODUCTS OTHER THAN COAL (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
21. (continued)		Domestic pottery[5]						
		Cups and saucers	Pr. number	3·85	4·32	5·50	6·07	6·20
		Plates	,,	4·20	4·96	6·10	6·57	6·60
		Others	,,	3·53	3·89	4·20	4·05	4·46
		Total: 21		16·21	18·98	23·00	24·22	25·00
22. Glass (other than containers)		Domestic and fancy glassware	Pr. value deflated[6]	c	c	2·30	c	c
and		Flat glass	Estimate	c	c	16·20	c	c
23. Glass containers		Glass containers	Pr. number	d	d	12·60	d	d
		Total: 22 + 23		25·87	26·81	31·10	33·23	34·98
24. Cement		Cement	Pr. tons	10·10	10·70	13·10	14·16	14·99
		Gypseous plaster	,,	0·42	0·41	0·50	0·55	0·62
		Total: 24		10·52	11·11	13·60	14·71	15·61
29. Other non-metalliferous mining manufactures		Concrete:						
		Artificial stone	G.B. Pr. cu. ft.	0·91	1·84	2·20	2·50	2·63
		Floor, roof and wall units and blocks	G.B. Pr. sq. yds.	0·84	2·13	2·70	2·57	2·33
		Pipes	G.B. Pr. tons	0·77	1·07	1·20	1·15	1·11
		Kerbs	G.B. Pr. lin. yds.	1·80	1·03	1·30	1·39	1·30
		Paving slabs	G.B. Pr. sq. yds.	0·99	1·70	2·80	2·92	2·32
		Asbestos cement goods:						
		Sheeting	G.B. Pr. tons	12·44	11·94	12·40	12·32	12·25
		Rainwater and all others	G.B. ,,	1·50	2·10	1·90	2·57	2·73
		Clinker	G.B. ,,	6·84	7·29	8·90	9·55	10·18
		Whiting	G.B. ,,	0·92	0·92	1·00	1·11	1·19
		Roofing felt	G.B. Pr. rolls	2·89	3·24	3·70	3·43	3·56
		Damp proof course felt	G.B. Pr. sq. ft.	0·87	0·80	0·70	0·90	0·96
		Deaths (*for* tombstones)	Number	0·94	0·99	0·90	0·97	0·97
		Manufactured fuel	Pr. tons	1·16	1·40	1·10	1·13	1·05
		Total: 29		32·87	36·45	40·80	42·51	42·58
Total—Treatment of Non-metalliferous Mining Products other than Coal				112·16	126·35	144·00	152·25	157·59

[5] Production of cups, saucers and plates for export counted twice, to allow for greater value added.

[6] Deflated by average hourly earnings, Min. List 22.

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Order IV.—Chemicals and Allied Trades

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at* 1948 *Prices* (£mn.) 1946	1947	1948	1949	1950
30.	Coke ovens and by-product works	Coke produced at coke ovens	Pr. tons	11·34	11·19	12·50	12·56	12·52
		Total: 30		11·34	11·19	12·50	12·56	12·52
31.	Chemicals and dyes	Synthetic dyestuffs	Pr. lbs.	c	c	c	c	c
		Ground basic slag	Pr. tons	0·36	0·36	0·40	0·43	0·45
		Superphosphates (P_2O_5 content)	,,	0·88	0·88	1·00	1·01	0·94
		Nitrogenous fertilizers (nitrogen content)	,,	4·45	4·38	4·80	5·25	5·50
		Compound fertilizers	,,	3·28	3·43	4·30	4·35	4·78
		Hydrochloric acid	Index	1·80	1·81	2·10	2·07	2·23
		Sulphuric acid	Pr. tons	7·53	7·56	8·80	9·42	10·22
		Nitric acid	,,	0·86	0·75	0·90	0·90	0·95
		Ammonia	,,	1·65	1·54	1·80	1·82	1·95
		Copper sulphate	,,	2·58	1·57	1·40	2·04	2·56
		Zinc oxide	,,	4·13	3·93	4·00	3·17	3·51
		Alkalis	Index	15·10	13·94	18·00	17·65	19·86
		Lead oxides	Pr. tons	2·61	2·45	2·70	2·63	2·84
		Oxygen	Pr. cu. ft.	2·55	2·73	3·40	3·64	4·00
		Acetylene	,,	1·34	1·46	1·80	1·87	1·97
		Chlorine	Index	2·53	2·50	3·20	2·96	3·57
		Plastics (acrylic sheet, casein and P.V.C.)	Pr. tons	17·06	20·00	22·10	24·85	37·27
		Synthetic resin	,,	1·83	2·18	2·40	2·10	2·79
		Coal tar distilled	,,	d	d	d	d	d
		Total: 31		88·11	89·89	105·50	105·81	128·05
32.	Pharmaceutical preparations, toilet preparations, perfumery	Medicinal preparations—estimated home consumption plus exports	Value deflated[7]	16·18	17·71	17·50	17·25	17·30
		Other drugs—exports	Do.[8]	5·72	5·62	6·00	7·22	9·46
		Prescriptions[9]	Number	8·80	10·08	12·00	15·08	17·31
		Toilet preparations	Sales, value deflated[10]	6·61	8·74	8·80	13·31	13·80
		Total: 32		37·31	42·15	44·30	52·86	57·87
33.	Explosives and fireworks (less Munitions [—1·3])	Industrial explosives	Index	8·91	9·76	11·40	12·15	12·54
		Total: (33 part)		8·91	9·76	11·40	12·15	12·54

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ORDER IV.—CHEMICALS AND ALLIED TRADES (*continued*)

Standard Industrial Classification (Minimum List)		*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)*				
Number	*Heading*			1946	1947	1948	1949	1950
34.	Paint and varnish	Paint and varnish	Employment × Productivity[11]	31·41	29·59	32·20	34·98	36·54
		Total: 34		31·41	29·59	32·20	34·98	36·54
35.	Soap, candles, glycerine, polishes, ink, and matches	Toilet soap	Del. tons	2·97	2·84	3·10	3·88	4·55
		Other soap	,,	14·37	13·75	14·60	16·27	17·86
		Soapless detergents	,,	c	c	c	c	c
		Wax deliveries to candle makers (*for* candles)	,,	d	d	d	d	d
		Polishes	Pr. cwt.	1·94	1·96	3·50	3·95	3·71
		Home consumption of newsprint (*for* printers' ink)	Cons. tons	0·55	0·64	0·60	0·87	0·99
		Matches	Pr. boxes	4·40	4·20	4·50	4·29	4·31
		Total: 35		25·36	24·70	28·00	31·38	33·96
36.	Mineral oil refining	Aviation, motor and white spirit	Pr. tons	1·29	0·92	1·70	2·39	3·45
		Kerosene	,,	0·06	0·15	0·20	0·22	0·27
		Gas and diesel oil	,,	0·73	0·66	1·40	1·92	3·05
		Fuel oil	,,	0·41	0·77	1·80	3·11	4·86
		Lubricating oil	,,	0·93	1·03	1·10	1·13	1·28
		Bitumen	,,	0·52	0·49	0·60	0·63	0·72
		Total: 36		3·94	4·02	6·80	9·40	13·63
39.	Other oils, greases, glue, etc.	Oilseeds and nuts processed	Tons	15·03	13·23	12·40	14·83	15·56
		Whale oil, herring and seal oil	Disposals, Tons	4·39	7·36	8·10	8·33	8·38
		Total: 39		19·42	20·59	20·50	23·16	23·94
	Total—Chemicals and Allied Trades			225·80	231·89	261·20	282·30	319·05

[7] Deflated by estimated price series.
[8] Deflated by average hourly earnings of men in pharmaceutical preparations, etc.
[9] National Health Service prescriptions plus allowance for other prescriptions.
[10] Deflated by export average value.
[11] See note (a)

ORDER V.—METAL MANUFACTURE

40.	Blast furnaces	Pig iron	Pr. tons	15·39	15·44	18·40	18·84	19·11
		Total: 40		15·39	15·44	18·40	18·84	19·11

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ORDER V.—METAL MANUFACTURE (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
41.	Iron and steel melting, rolling etc., not elsewhere specified	Steel melting and rolling	Index	106·62	109·31	126·70	133·77	140·91
		Total: 41		106·62	109·31	126·70	133·77	140·91
42.	Iron foundries	Cast iron pipes, rainwater pipes	Pr. tons	5·15	6·15	7·10	8·05	8·47
		Municipal castings	,,	1·32	1·53	1·60	1·67	1·78
		Boiler, radiator, furniture and builders' ironmongery	,,	2·12	2·54	2·60	2·75	2·90
		Stoves (solid fuel), sanitary goods	,,	5·64	6·83	7·90	8·07	8·92
		Gas and electric stove castings	,,	2·70	2·96	3·50	3·25	3·83
		Other castings (engineering)	,,	32·57	35·73	41·50	41·86	42·41
		Total: 42		49·50	55·74	64·20	65·65	68·31
43.	Sheets and tinplate	Tin, terne and blackplate	Pr. tons	8·13	9·23	10·20	10·42	10·63
		Total: 43		8·13	9·23	10·20	10·42	10·63
44.	Iron and steel tubes (including melting and rolling in integrated works)	Wrought iron and steel tubes, pipes and fittings	Pr. tons	20·27	19·68	21·10	26·56	29·08
		Total: 44		20·27	19·68	21·10	26·56	29·08
49.	Non-ferrous metals smelting, rolling, etc.	Non-ferrous metal manufacture	Index (C.S.O.)	58·96	66·62	67·80	64·85	72·52
		Total: 49		58·96	66·62	67·80	64·85	72·52
	Total—Metal Manufacture			258·87	276·02	308·40	320·09	340·56

ORDER VI.—ENGINEERING, SHIPBUILDING AND ELECTRICAL GOODS

50.	Shipbuilding and ship repairing *and*	Shipbuilding[12]	Tons gross	d	d	76·00	d	d
51.	Marine engineering (less Munitions[14] [—29·6])	Ship repairing	Estimated employment[13]	c	c	44·00	c	c
		Total: 50 part and 51 part		115·32	115·25	120·00	118·00	112·61

ORDER VI.—ENGINEERING, SHIPBUILDING AND ELECTRICAL GOODS (*continued*)

Standard Industrial Classification (Minimum List)		*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)*				
Number	*Heading*			1946	1947	1948	1949	1950
52.	Agricultural machinery (except tractors)	Agricultural machinery (excluding tractors)[15]	Index	10·05	12·77	18·30	19·73	25·31
		Total: 52		10·05	12·77	18·30	19·73	25·31
53.	Boilers and boiler-house plant	Water tube and shell boilers and steam-raising plant accessories	Pr. value deflated[16]	18·59	18·54	22·00	23·23	23·67
		Total: 53		18·59	18·54	22·00	23·23	23·67
54.	Machine tools	Metal working machine tools and engineers' small tools	Del. value deflated[17]	33·90	38·48	40·70	37·10	39·82
		Welding sets—arc	Del. number	0·65	1·00	1·20	0·81	0·80
		resistance	,,	0·70	0·88	0·60	0·53	0·50
		Total: 54		35·25	40·36	42·50	38·44	41·12
55.	Stationary engines	Internal combustion engines (excluding those for vehicles, aircraft and large ships)	Del. B.H.P.	6·31	11·39	13·20	16·78	20·55
		Hydraulic turbines	,,	1·14	1·01	0·60	3·56	4·65
		Total: 55		7·45	12·40	13·80	20·34	25·20
56.	Textile machinery and accessories	Hosiery and other textile machinery	Pr. value deflated[18]	22·51	29·83	39·30	42·82	41·82
		Total: 56		22·51	29·83	39·30	42·82	41·82
57.	Ordnance and small arms (less Munitions [−16·9])	Civil and export work	Assumed series	3·80	3·80	4·00	4·20	4·32
		Total: 57 (part)		3·80	3·80	4·00	4·20	4·32

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ORDER VI.—ENGINEERING, SHIPBUILDING AND ELECTRICAL GOODS (*continued*)

Standard Industrial Classification (Minimum List)		*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)*				
Number	*Heading*			1946	1947	1948	1949	1950
58.	Constructional engineering	Metal temporary houses:						
		Aluminium hulls	Pr. number	7·08	17·12	4·20	0·00	0·00
		Other hulls	,,	26·83	1·49	0·00	0·00	0·00
		Constructional engineering (*for* rest of trade)	Employment × productivity[19]	10·46	11·31	12·00	12·44	12·91
		Total: 58		44·37	29·92	16·20	12·44	12·91
69.	Other non-electrical engineering	Gas meters	Pr. number	1·58	1·87	2·30	2·24	2·45
		Coal cutters	Del. number	1·25	1·41	1·50	1·38	1·07
		Coal loaders	,,	0·15	0·14	0·20	0·15	0·12
		Coal conveyors	,,	2·50	2·71	4·10	3·86	3·08
		Crawler excavators	,,	2·94	2·62	3·70	4·12	4·47
		Typewriters	,,	0·70	0·82	1·10	1·66	2·33
		Sewing machines	Home supplies plus exports less imports —number	1·92	2·73	3·60	3·52	4·47
		Lawn mowers	Pr. value deflated[20]	1·00	1·59	1·40	1·69	2·50
		Non-electrical engineering (other)—deliveries of machines[21]	Del. value deflated[22]	38·94	53·97	69·60	79·15	85·34
		Iron castings for chemical plant	Input, tons	3·31	4·05	4·70	5·12	5·21
		Iron castings for gas plant	,,	2·59	3·19	3·20	3·31	3·34
		Other non-electrical engineering[23]	See notes	99·73	125·33	153·80	164·80	177·90
		Total: 69		156·61	200·43	249·20	271·00	292·28
70.	Electrical machinery	Rotating electrical machinery and electrical control gear	Del. value deflated[24]	32·37	32·44	47·80	49·54	47·34
		Steam turbines and turbo-alternators	Del. K.W.	7·51	8·91	12·20	14·72	18·05
		Total: 70		39·88	41·35	60·00	64·26	65·39
71.	Electrical wires and cables	Insulated wires and cables	Pr. value deflated[25]	34·57	36·94	42·30	46·34	40·71
		Total: 71		34·57	36·94	42·30	46·34	40·71
72.	Telegraph and telephone apparatus	Telegraph apparatus (excluding wireless) exported	Value deflated[26]	6·92	8·57	14·40	18·72	18·36

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ORDER VI.—ENGINEERING, SHIPBUILDING AND ELECTRICAL GOODS (*continued*)

Standard Industrial Classification (Minimum List)		*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)*				
Number	*Heading*			1946	1947	1948	1949	1950
72. (continued)		Telegraph apparatus for home use:						
		Post Office " stations " added	Number	10·56	9·45	10·00	6·95	6·11
		Total number of stations	,,	10·15	11·14	12·00	12·69	13·34
		Total mileage of P.O. single wire (Last two indicators *for* repairs and replacements)	Miles	11·44	11·68	12·00	12·51	12·94
		Total: 72		39·07	40·84	48·40	50·87	50·75
73.	Wireless apparatus (except valves) and gramophones	Radio sets	Pr. number	21·17	30·40	25·00	20·61	27·24
		Television sets	,,	0·37	1·65	5·30	12·33	31·52
		Total: 73		21·54	32·05	30·30	32·94	58·76
74.	Wireless valves and electric lamps	Radio valves	Pr. number	5·35	6·77	8·30	6·82	9·59
		Lamp bulbs	Del. number	10·38	10·60	13·40	12·80	13·89
		Fluorescent lamps	Pr. number	0·50	1·49	2·50	3·12	3·50
		Total: 74		16·23	18·86	24·20	22·74	26·98
75.	Batteries and accumulators	Dry cells	Pr. unit cells	2·70	3·12	2·60	2·59	2·43
		Accumulators	Del. value deflated[27]	8·00	6·91	7·10	7·89	7·90
		Total: 75		10·70	10·03	9·70	10·48	10·33
79.	Other electrical goods	Electric cookers	Pr. number	4·92	7·12	8·00	6·73	8·30
		Electric fires, bed-warmers, blankets and pads	,,	2·81	1·87	0·50	0·48	0·43
		Vacuum cleaners	Del. number	7·45	9·92	7·10	8·76	11·49
		Electric irons	,,	3·53	2·53	1·80	1·68	2·03
		Electric meters	Pr. number	4·09	5·98	6·30	4·44	5·04
		Electric washboilers and waterheaters	,,	3·18	2·93	1·80	1·50	1·87
		Electric kettles	Del. number	1·04	1·28	0·80	0·65	0·76

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Order VI.—Engineering, Shipbuilding and Electrical Goods (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
79. (continued)	Electric fans	Pr. number		1·37	1·34	1·20	1·19	1·05
	Total: 79			28·39	32·97	27·50	25·43	30·97
	Total—Engineering, Shipbuilding and Electrical Goods			604·33	676·34	767·70	803·26	863·13

[12] Vessels commenced, launched and completed—moving average.
[13] No productivity adjustment.
[14] Transfer to Munitions [29·6] for the two industries together.
[15] Twelve production series combined, using weights from Census of Production average values.
[16] Deflated by export average value of water tube boilers and other boilers.
[17] Deflated by export average value of machine tools (metal working) other than portable power tools.
[18] Deflated by export average value of textile machinery.
[19] See note (a)
[20] Deflated by export average value of lawn mowers.
[21] Including printing and book-binding machinery, conveyors and elevators, cranes, other mechanical handling equipment, accounting machines, other office machinery, woodworking tools, air and gas compressors, pumps, refrigerating machinery, tobacco machinery, water treatment plant, industrial valves, industrial furnaces, tanning machinery, brick and pottery machinery, stone working machinery, mattress machinery, laundry plant, etc.
[22] Deflated by average of index of hourly earnings for men in mechanical engineering and index of cost of materials used.
[23] Residual weight moved with totals for 52 to 58 inclusive, and total of 69 above.
[24] Deflated by average of index of hourly earnings for men in electrical engineering and index of cost of materials used.
[25] Deflated by export average value of "telegraph cables, other" and "electric wire, rubber insulated".
[26] Deflated by average of index of hourly earnings for men in electrical engineering and index of cost of materials used.
[27] Deflated by export average value of accumulators for motor vehicles and traction purposes.

Order VII.—Vehicles

80. Manufacture of motor vehicles and cycles (part) (less Munitions [−15·0])	Passenger cars[28]	Pr. number						
	Up to 8 h.p.		14·27	15·69	15·90	54·14	68·22
	8 h.p. to 12 h.p.		21·35	28·53	30·10		
	12 h.p. to 16 h.p.		8·84	15·74	21·00	23·41	28·38
	Over 16 h.p.		2·57	3·78	11·30	27·22	37·36
	Commercial vehicles:						
	Less than 15 cwt.		9·57	11·43	12·20	19·07	23·73
	15 cwt. to 6 tons		26·19	25·12	28·10	30·80	38·62
	Over 6 tons		2·38	2·07	3·10	3·67	3·46
	Public service vehicles		20·85	27·58	27·80	31·49	24·54
	Electric road vehicles		0·43	0·55	0·60	0·35	0·25
	Trailers		0·44	0·41	0·40	0·39	0·47
	Motor cycles		5·18	6·24	7·30	8·54	9·56
	Pedal cycles		11·43	13·48	15·90	19·02	19·08
	Market garden tractors		0·62	0·95	1·20	0·90	1·08
	Other tractors		6·35	12·59	25·00	19·31	25·68
	Total: 80 (part)		130·47	164·16	199·90	238·31	280·43

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ORDER VII.—VEHICLES (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
81.	Motor repairers and garages (part) *and*	Repairs—motor[29]		45·65	45·65	35·00	34·24	36·52
83.	Manufacture of parts and accessories for motor vehicles and aircraft (part) (less transfer to distribution, order XX [—45·0])	Spares—motor (*for* manufacture)[29]		16·33	16·47	16·20	18·51	20·42
		Total: 81 (part) + 83 (part)		61·98	62·12	51·20	52·75	56·94
82.	Manufacture and repair of aircraft (part) *and*	Production of aircraft:						
83.	Manufacture of parts and accessories for motor vehicles and aircraft (part) (less Munitions [—46·6])	Airframe structure weight (civil and all export)	Index	24·19	21·38	18·00	19·13	17·10
		Conversion of military aircraft to civil types	Number	3·48	4·41	0·50	0·41	0·21
		U.K. airways—ton-miles flown (*for* spares and repairs)		1·91	2·31	3·00	3·31	4·14
		Aircraft engines and other accessories (*for* spares exported)	Exports value deflated[30]	5·20	6·12	6·00	7·14	9·62
		Total: 82 (part) + 83 (part)		34·78	34·22	27·50	29·99	31·07
84.	Railway locomotive shops	Steam locomotives, main line	Pr. number	13·04	10·92	12·50	13·23	12·81
85.	Other locomotive manufacture	Coaching vehicles	,,	5·68	8·62	9·70	13·37	21·24
86.	Manufacture and repair of railway carriages and wagons and trams	Wagons	,,	15·65	15·15	18·10	15·26	13·18
		Colliery tubs and cars	Del. number	1·56	1·95	2·10	2·10	2·01
		Telegraph, track, brake and signal equipment	Pr. value deflated[31]	1·69	1·74	2·10	2·34	2·06
		Total: 84 + 85 + 86		37·62	38·38	44·50	46·30	51·30
89.	Carts, perambulators, etc.	Prams and folders	Pr. number	7·89	10·14	9·00	8·25	6·27
		Push chairs	,,	4·22	3·18	3·70	3·69	3·02
		Total: 89		12·11	13·32	12·70	11·94	9·29
	Total—Vehicles			276·96	312·20	335·80	379·29	429·03

[28] The horse-power classification is assumed to correspond roughly to that currently used, as follows: 12 h.p. = 1,600 c.c.; 16 h.p. = 2,200 c.c.
[29] Based on trade information.
[30] Deflated by hourly earnings of men in aircraft manufacture and repair.
[31] Deflated by average of indices of hourly earnings for men in mechanical and electrical engineering and of cost of materials.

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Order VIII.—Metal Goods Not Elsewhere Specified

Standard Industrial Classification (Minimum List) Number	Heading	Indicator		Estimated Value Added at 1948 Prices (£mn.) 1946	1947	1948	1949	1950
90.	Tools and cutlery	Hand tools	Exports, value deflated[32]	13·02	14·28	16·10	17·82	18·49
		Order I index (*for* agricultural tools)		3·16	3·19	3·50	3·72	3·41
		Order XVII index (*for* building tools)		12·47	13·56	14·80	16·12	16·38
		Spoons and forks	Pr. number	1·61	1·88	2·00	—	—
		Knives (carving, table and folding)	,,	2·84	3·60	3·20	—	—
		Cutlery (total)	Pr. value deflated[33]	—	—	—	4·88	5·02
		Razor blades, safety	Pr. number	4·01	4·30	3·30	4·06	4·41
		Razor holders, safety	,,	1·43	0·94	0·80	1·09	1·57
		Total: 90		38·54	41·75	43·70	47·69	49·28
91.	Bolts, nuts, screws, rivets, nails, etc.	Steel for bolts, nuts, rivets	Del. tons	18·32	19·05	22·10	22·97	21·50
		Total: 91		18·32	19·05	22·10	22·97	21·50
92.	Iron and steel forgings, not elsewhere specified	Steel for springs	Del. tons	4·66	5·25	6·90	7·44	7·64
		Iron and steel forgings	Employment × productivity[34]	19·18	21·30	23·20	23·98	24·69
		Total: 92		23·84	26·55	30·10	31·42	32·33
93.	Wire and wire manufactures	Steel wire	Pr. tons	20·43	18·87	22·50	26·31	27·70
		Total: 93		20·43	18·87	22·50	26·31	27·70
94.	Hollow-ware	(Kettles, saucepans, stewpans, frypans)[35], dustbins, buckets, bowls and " baths ", fireguards	Pr. number	15·41	13·68	11·40	10·62	11·58
		Domestic aluminium hollow-ware	Exports cwt.	3·78	6·28	3·50	5·12	4·41
		Tinplate " consumption " (*for* metal containers, etc.)	Production less exports. Tons	40·93	45·49	47·00	51·05	49·16
		Total: 94 + 99 (1) part		60·12	65·45	61·90	66·79	65·15
95.	Brass manufactures	Brass and other alloy products (as input)	Pr. tons	15·26	17·10	16·00	13·42	15·57
		Total: 95		15·26	17·10	16·00	13·42	15·57

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ORDER VIII.—METAL GOODS NOT ELSEWHERE SPECIFIED (*continued*)

Standard Industrial Classification (Minimum List)		*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)*				
Number	*Heading*			1946	1947	1948	1949	1950
99.	Metal industries not elsewhere specified. (Part of weight "carried" by other industries in the Order)	Utility bedsteads[36]	Del. number	1·17	0·86	1·10	1·26	1·26
		Metal casements, doors, etc.	Pr. ft. super	9·54	12·55	9·50	11·34	11·97
		Needles and fish hooks	Pr. value deflated[37]	0·76	0·92	1·20	1·18	1·28
		Buttons and buckles	Pr. number	1·38	1·54	1·30	1·34	1·40
		Mechanical lighters	,,	1·61	1·14	0·80	0·84	0·93
		Metal furniture	Pr. value deflated[38]	5·27	7·09	8·00	6·23	6·18
		Total: 99		19·73	24·10	21·90	22·19	23·02
		Total—Metal Goods not elsewhere specified		196·24	212·87	218·20	230·79	234·55

[32] Deflated by special export price index.
[33] Deflated by hourly earnings of men, Min. List 90.
[34] See note (a)
[35] For home civilian market only.
[36] For home civilian market only.
[37] Deflated by assumed price series.
[38] Deflated by average of index of hourly earnings, men, and index of price of steel sheet.

ORDER IX.—PRECISION INSTRUMENTS, JEWELLERY, ETC.

100. Scientific, surgical and photographic instruments, etc.	Scientific instruments, etc.	Employment × productivity[39]	29·50	30·58	31·70	34·96	37·68
	Ophthalmic lenses[40]	Pr. number	2·54	2·77	3·00	4·04	5·13
	Total: 100		32·04	33·35	34·70	39·00	42·81
101. Manufacture and repair of watches and clocks	Clocks:						
	Mechanical and car.	Pr. number	2·12	3·28	4·90	7·45	7·25
	Electric	,,	4·02	5·24	3·40	2·43	2·39
	Watches[41]	,,	0·05	0·22	0·70	1·07	1·81
	Watch repairing	Assumed series	9·00	9·50	10·00	10·00	10·00
	Total: 101		15·19	18·24	19·00	20·95	21·45
102. Jewellery, plate and refining of precious metals	Plate and jewellery	Sales (excluding P.T.)—value deflated[42]	10·77	12·04	10·10	9·77	8·43
	Total: 102		10·77	12·04	10·10	9·77	8·43

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ORDER IX.—PRECISION INSTRUMENTS, JEWELLERY, ETC. (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
103.	Musical instruments	Musical instruments	Employment × productivity[43]	2·35	2·95	3·10	3·10	3·21
		Total: 103		2·35	2·95	3·10	3·10	3·21
	Total—Precision Instruments, Jewellery, etc.			60·35	66·58	66·90	72·82	75·90

[39] See note (a)
[40] Estimated.
[41] Assembly from imported components × ¼ + production.
[42] Deflated by hourly earnings, Min. List 102.
[43] See note (a)

ORDER X.—TEXTILES

110.	Cotton spinning, doubling, etc.	Waste yarns	Pr. lbs.	1·62	1·62	1·90	1·98	2·07
		Singles—up to 16s	,,	8·99	8·87	10·70	10·34	11·18
		17s to 20s	,,	3·43	3·31	4·10	4·54	4·67
		21s to 26s	,,	3·60	3·38	3·90	4·30	4·32
		27s to 80s	,,	12·74	13·35	15·90	17·33	17·66
		80s to 120s	,,	2·26	2·25	2·50	2·26	1·99
		over 120s	,,	0·30	0·31	0·40	0·24	0·24
		Doubles—up to 26s	,,	9·68	9·51	11·70	10·49	11·34
		over 26s	,,	9·32	9·97	11·90	12·15	12·69
		Cotton mixture yarns and spun rayon yarns	,,	1·45	1·73	2·20	2·63	3·68
		Total: 110		53·39	54·30	65·20	66·26	69·84
111.	Cotton weaving, etc.	Tyre cords	Pr. lin. yds.	1·18	1·12	1·50	1·36	1·54
		Canvas and duck	,,	2·20	1·68	1·90	1·80	1·86
		Surgical dressings	,,	5·28	4·99	4·50	4·60	4·94
		Cleaning and dish cloths	,,	0·72	0·73	0·80	0·93	0·86
		Other grey cloth	,,	27·64	28·61	34·80	36·95	39·26
		Terry and coloured towelling	,,	2·86	2·40	2·80	3·12	3·35
		Other coloured cloth	,,	0·89	0·92	1·20	1·33	1·39
		Total: 111		40·77	40·45	47·50	50·09	53·20
112.	Woollen and worsted	Wool blankets	Del. sq. yds.	1·93	1·65	1·80	1·69	1·80
120.	Carpets	Woven wool fabrics	,,	52·99	54·98	63·50	67·18	68·97
		Wool tops	Pr. lbs.	7·00	8·10	9·70	10·05	11·10
		Worsted yarn—hand knitting	,,	1·41	1·61	1·80	26·16	28·49
		other	,,	18·14	19·13	22·60		

ORDER X.—TEXTILES (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
112, 120. (continued)		Wool carpets and rugs	Pr. sq. yds.	5·90	8·70	11·20	12·85	14·86
		Total: 112 + 120		87·37	94·17	110·60	117·93	125·22
113.	Rayon, nylon, etc., production	Rayon—continuous filament yarn (single)	Pr. lbs.	19·42	21·44	26·70	30·96	35·74
		staple fibre	,,	3·87	4·56	4·70	6·40	9·47
114.	Rayon, nylon, etc., weaving and silk	Raw silk	Cons. lbs.	1·07	1·76	1·70	2·22	2·18
		Rayon and nylon cloth	Pr. lin. yds.	7·38	7·97	10·30	12·18	14·72
		Cotton/rayon/nylon mixtures	,,	0·98	1·26	1·70	1·98	2·29
		Total: 113 + 114		32·72	36·99	45·10	53·74	64·40
115.	Linen and soft hemp	Line and machine tow	Cons. tons	5·49	5·96	6·50	6·68	7·51
		Low grade tow	,,	0·64	0·88	0·70	0·72	0·71
		Linen and union cloth (N. Ireland)	Pr. lin. yds.	c	c	c	c	c
		Linen, etc. (G.B.)	Employment × productivity[44]	d	d	d	d	d
		Total: 115		16·64	18·10	19·10	19·81	21·23
116.	Jute	Jute yarn	Pr. tons	c	c	1·30	c	c
117.	Rope, twine and net	Jute cloth	,,	c	c	4·80	c	c
		Hard hemp	Cons. tons	d	d	4·30	d	d
		Soft hemp (excluding paper usage)	,,	d	d	0·80	d	d
		Cotton yarn for cordage	Del. tons	d	d	0·80	d	d
		Total: 116 + 117		11·52	11·97	12·00	10·60	12·45
118.	Hosiery and other knitted goods	Stockings—men's and youths'	Pr. pairs	2·43	2·65	3·20	3·64	4·30
		women's and maids'	,,	12·02	13·26	15·30	16·88	17·77
		children's, and knitted gloves	,,	1·30	1·31	1·50	1·64	1·84
		Pullovers and cardigans—men's	Pr. number	1·28	1·44	1·80	2·37	2·91
		Vests, pants and trunks—men's	,,	4·08	4·23	5·50	5·76	5·94
		Jumpers and cardigans—women's	,,	2·30	3·07	3·50	4·98	6·77
		Vests, knickers and pants—women's	,,	5·75	6·71	7·80	8·86	7·88
		Outerwear—children's	,,	1·10	1·14	1·20	1·27	1·54
		Underwear—children's and infants'		2·39	2·80	3·30	3·31	3·18

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ORDER X.—TEXTILES (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
118. (continued)		Outerwear—infants'	Pr. number	0·93	0·99	1·20	1·02	0·83
		Total: 118		33·58	37·60	44·30	49·73	52·96
119. Lace		Lace	Employment × productivity[45]	4·69	5·49	7·10	7·81	8·58
		Total: 119		4·69	5·49	7·10	7·81	8·58
120. Carpets		See 112						
121. Narrow fabrics		Rayon yarn, for narrow fabrics	Del. lbs.	1·47	1·52	1·60	—	—
		Cotton yarn, for narrow fabrics (Indicators replaced by —)	,,	6·96	5·84	6·40	—	—
		Narrow fabrics	Employment × productivity[46]	—	—	—	8·33	8·89
		Total: 121		8·43	7·36	8·00	8·33	8·89
122. Made-up textiles		Jute cloth	Cons. tons	4·69	5·12	6·00	4·71	3·99
		Cotton cloth	Pr. lin. yds.	1·80	1·80	2·10	2·22	2·35
		Total: 122		6·49	6·92	8·10	6·93	6·34
123. Textile finishing, etc.		Cotton and rayon:						
		Yarn processing	G.B. Pr. lbs.	4·80	5·04	5·90	6·21	6·78
		Dyeing	G.B. Pr. yds.	12·95	12·79	15·40	17·83	20·06
		Printing	,,	9·60	10·25	14·20	17·15	19·03
		Finishing	,,	0·66	0·75	0·80	0·89	0·94
		Raising	,,	0·98	0·94	1·00	1·06	1·24
		Textile exports, volume (*for* packing)	Index	1·29	1·33	1·70	1·87	2·17
		Total: 123		30·28	31·10	39·00	45·01	50·22
129. Other textile industries		Asbestos, raw and fibre	Imports, tons	6·77	8·39	10·90	11·59	13·80
		Mungo and shoddy	Cons. lbs.	3·78	3·46	3·80	3·92	5·06
		Coir matting	Pr. sq. yds.	1·22	1·36	1·40	1·29	0·99

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ORDER X.—TEXTILES (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
129. (continued)	Cow, horse and hog hair		Imports, cwt.	1·94	2·29	2·10	2·24	1·82
	Total: 129			13·71	15·50	18·20	19·04	21·67
Total—Textiles				339·59	359·95	424·20	455·08	495·00

[46] See note (a)

[46] See note (a)

[46] See note (a)

ORDER XI.—LEATHER, LEATHER GOODS AND FUR

130. Leather (tanning and dressing) and fellmongery	Finished leather		Pr. index	26·90	30·53	31·00	31·07	30·13
	Sheepskins		Pr. tons	1·01	0·91	0·90	0·96	0·98
	Total: 130			27·91	31·44	31·90	32·03	31·11
131. Leather goods	Leather goods		Sales deflated[47]	7·11	7·60	6·30	5·59	6·19
	Total: 131			7·11	7·60	6·30	5·59	6·19
132. Fur	Fur		Employment × productivity[48]	3·12	3·51	3·90	3·78	4·10
	Total: 132			3·12	3·51	3·90	3·78	4·10
Total—Leather, Leather Goods and Fur				38·14	42·55	42·10	41·40	41·40

[47] Deflated by hourly earnings, Min. List 131.

[48] See note (a)

ORDER XII.—CLOTHING

140. Tailoring 141. Dressmaking 142. Overalls, shirts, underwear, etc. 143. Hats, caps and millinery 147. Dress industries not elsewhere specified 148. Manufacture of boots, shoes, slippers, and clogs (excluding rubber)	Clothing		Pr. Index (C.S.O.)	166·07	177·70	186·00	204·27	210·91
	Total: 140, 141, 142, 143, 147, 148			166·07	177·70	186·00	204·27	210·91

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Standard Industrial Classification (Minimum List) Number	Heading	Indicator		Estimated Value Added at 1948 Prices (£mn.) 1946	1947	1948	1949	1950
		ORDER XII.—CLOTHING (*continued*)						
149.	Repair of boots and shoes	Boot and shoe repairs	Consumers' expenditure at constant prices	24·49	25·00	25·00	23·98	23·98
		Total: 149		24·49	25·00	25·00	23·98	23·98
	Total—Clothing			190·56	202·70	211·00	228·25	234·89
		ORDER XIII.—FOOD, DRINK AND TOBACCO						
150.	Grain milling	Flour	Pr. tons	20·71	20·80	21·40	20·97	19·68
		Offals (wheat)	,,	2·58	2·72	2·80	2·72	2·87
		Oats processed	,,	2·15	2·17	1·90	1·72	1·38
		Maize for animal food	Cons. tons	0·25	0·41	1·60	1·42	1·33
		Maize—other	,,	0·37	0·65	0·90	0·82	1·09
		Breakfast cereals	Pr. tons	1·31	1·58	2·10	2·20	1·89
		Total: 150		27·37	28·33	30·70	29·85	28·24
151.	Bread and flour confectionery *and*	Bread	Household cons. tons	c	c	c	c	c
		Cakes	,, ,,	c	c	c	c	c
152.	Biscuits	Biscuits	Pr. tons	d	d	d	d	d
		Total: 151 and 152		96·34	102·46	105·60	100·42	94·85
153.	Meat and meat products	Home-killed meat and bacon (*for* slaughtering)	Pr. tons	d	d	d	d	d
		Issues of manufacturing meat other than to butchers	G.B. tons	c	c	c	c	c
		Bacon and ham	Pr. tons	7·50	5·29	6·10	10·47	13·98
		Total: 153		15·88	13·70	14·60	18·11	24·91
154.	Milk products (less bottling, to order XX, [—4·0])	Butter (excluding farm)	Pr. tons	4·20	2·60	3·20	4·00	6·40
		Cheese	,,	6·91	4·61	7·20	9·22	15·26
		Condensed milk	,,	11·18	8·43	12·00	14·13	18·45
		Milk powder	,,	d	d	d	d	d
		Ice cream	Household cons. tons	c	c	c	c	c
		Total: 154 (part)		34·68	27·64	36·10	41·45	55·40

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ORDER XIII.—FOOD, DRINK AND TOBACCO (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
155.	Sugar and glucose	Sugar	Entered for home cons. Cwt.	7·22	8·63	10·90	11·13	11·26
		Sugar from home-grown beet	Pr. tons	2·73	3·52	2·90	2·90	3·27
		Glucose	,,	0·45	0·52	0·50	0·65	0·62
		Cane and beet molasses	,,	0·43	0·53	0·50	0·56	0·51
		Total: 155		10·83	13·20	14·80	15·24	15·66
156.	Cocoa, chocolate and sugar confectionery	Cocoa, national milk cocoa, drinking chocolate	Pr. tons	1·62	1·74	1·90	2·00	2·20
		Chocolate confectionery	,,	15·36	18·43	15·00	19·23	20·19
		Sugar confectionery	,,	9·99	11·96	11·30	14·54	14·44
		Total: 156		26·97	32·13	28·20	35·77	36·83
157.	Preserving of fruit and vegetables	Jam and marmalade	Pr. tons	10·75	11·36	12·50	13·40	10·99
		Canned and bottled fruit	,,	c	c	6·20	c	c
		Canned and bottled vegetables	,,	c	c	1·00	c	c
		Pickles and sauces	Household cons. tons	c	c	4·80	c	c
		Jellies	,, ,,	c	c	0·70	c	c
		Potato crisps	,, ,,	c	c	0·70	c	c
		Total: 157		18·97	22·04	25·90	29·34	25·73
162.	Food industries not elsewhere specified	Margarine	Pr. tons	3·72	3·98	4·50	4·74	4·21
		Compound cooking fat	,,	1·01	1·25	1·50	1·81	1·89
		Fish	G.B. Landed weight, tons	1·41	1·56	1·60	1·54	1·36
		and Fish going into pickle for cure (jointly representing fish curing and ice)	,,	c	c	1·60	c	c
		Flour for dog biscuits	Cons. tons	c	c	1·00	c	c
		Maize for animal feeding stuffs	,,	0·89	1·48	5·90	5·14	4·83
		Molasses for animal feeding stuffs	,,	0·74	0·86	1·00	1·29	1·43
		Starch	Pr. tons	c	c	2·00	c	c

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ORDER XIII.—FOOD, DRINK AND TOBACCO (*continued*)

Standard Industrial Classification (Minimum List)		*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)*				
Number	*Heading*			1946	1947	1948	1949	1950
162. (continued)		Fish paste	Household cons. tons	c	c	0·90	c	c
		Shredded suet	,,	c	c	0·40	c	c
		Vinegar	,,	c	c	1·80	c	c
		Mustard	,,	c	c	0·40	c	c
		Mincemeat, Christmas and canned puddings	,,	c	c	1·60	c	c
		Cake and bun mixes	,,	c	c	0·90	c	c
		Infant and invalid food	,,	c	c	2·80	c	c
		Coffee essence	,,	c	c	1·90	c	c
		Canned soup	,,	c	c	2·00	c	c
		Baking powder	,,	c	c	0·50	c	c
		Total: 162		23·45	25·40	32·30	30·31	27·90
163. Brewing and malting 164. Wholesale bottling (part) (beer)		Beer	Pr. bulk barrels	113·94	110·81	105·00	97·85	93·83
		Total: 163 and 164 (part)		113·94	110·81	105·00	97·85	93·83
164. Wholesale bottling (part) 168. Other drink industries		Spirits, charged with duty and free of duty for export	Proof gallons	9·50	10·17	11·00	11·33	13·11
		Spirits, total distilled in U.K.	,,	3·79	4·56	5·10	5·16	6·95
		Sweets, charged with duty and free of duty	Gallons	1·02	1·28	1·20	1·21	1·48
		Cider	Pr. gallons	c	c	c	c	c
		Soft drinks	,,	c	c	c	c	c
		Total: 164 (part) and 168		25·96	28·71	31·10	33·51	34·78
169. Tobacco		Tobacco	Entered for home cons., lbs.	54·17	48·86	45·40	45·33	45·30
		Total: 169		54·17	48·86	45·40	45·33	45·30
Total—Food, Drink and Tobacco				448·56	453·28	469·70	477·18	483·43

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Standard Industrial Classification (Minimum List) Number	Heading	Indicator		Estimated Value Added at 1948 Prices (£mn.) 1946	1947	1948	1949	1950
	ORDER XIV.—MANUFACTURES OF WOOD AND CORK							
170 (1).	Timber—Sawmilling, etc.	Softwood	Pr. + cons. standards	18·29	16·37	18·40	18·99	16·96
		Hardwood	Pr. + cons. cu. ft.	18·82	17·82	19·20	21·46	25·21
		Pitwood	Pr. standards	1·91	0·93	1·10	1·09	1·00
		Constructional plywood	Pr. sq. ft.	13·30	12·36	14·30	14·93	14·67
		Total: 170 (1)		52·32	47·48	53·00	56·47	57·84
170 (2).	Timber—other woodwork for buildings	See 173						
171.	Furniture and upholstery	Mattresses	Pr. number	3·67	3·49	4·00	4·26	4·31
		Furniture—utility	Index	32·48	35·73	39·30	50·02	55·54
		Total: 171		36·15	39·22	43·30	54·28	59·85
172.	Shop and office fitting	Shop and office fitting	Employment × productivity[49]	6·86	7·08	7·30	7·59	7·63
		Total: 172		6·86	7·08	7·30	7·59	7·63
170 (2).	Timber—other woodwork for buildings *and*	Wooden containers and baskets, *and* Miscellaneous wood and cork manufactures	Employment × productivity[50]	17·13	17·51	18·30	18·88	19·54
173.	Wooden containers and baskets *and*							
179.	Miscellaneous wood and cork manufactures							
		Total: 170 (2) + 173 + 179		17·13	17·51	18·30	18·88	19·54
	Total—Manufactures of Wood and Cork			112·46	111·29	121·90	137·22	144·86
		[49] See note (a)		[50] See note (a)				
	ORDER XV.—PAPER AND PRINTING							
180	Paper and board	Newsprint	Pr. tons	3·36	2·88	3·40	5·28	6·20
		Other printing and writing paper	,,	11·12	11·64	12·10	14·12	16·94
		Packing paper[51]	,,	5·92	5·96	6·40	6·75	8·20

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ORDER XV.—PAPER AND PRINTING (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
180. (continued)		Board	Pr. tons	9·59	9·24	10·90	12·46	13·65
		Other paper[51]	,,	2·49	2·54	2·80	2·98	3·24
		Total: 180		32·48	32·26	35·60	41·59	48·23
181. Wallpaper		Wallpaper	Employment × productivity[52]	2·30	2·50	2·40	3·50	3·99
		Total: 181		2·30	2·50	2·40	3·50	3·99
182. Cardboard boxes, cartons, and fibre-board packing cases		Cardboard boxes, etc.	Employment × productivity[53]	10·13	11·93	12·60	14·15	16·67
		Total: 182		10·13	11·93	12·60	14·15	16·67
183. Manufactures of paper and board not elsewhere specified *and*		Other printing and writing paper	Cons. tons	82·96	86·93	90·30	104·60	126·75
189. Other printing and publishing, book-binding, engraving, etc.		Books[54]	See notes	12·36	12·78	13·60	13·19	14·01
		Total: 183 + 189		95·32	99·71	103·90	117·79	140·76
186. Printing and publishing of newspapers and periodicals		Newsprint	Cons. tons	27·36	30·68	29·70	43·16	49·10
		Newspapers and magazines[55]	See notes	25·31	28·20	29·80	33·32	35·57
		Total: 186		52·67	58·88	59·50	76·48	84·67
189. Other printing and publishing, bookbinding, engraving, etc.		See 183						
Total—Paper and Printing				192·90	205·28	214·00	253·51	294·32

[51] Greaseproof paper and tissue paper included in "other paper".
[52] See note (a)
[53] See note (a)
[54] Sales to personal consumers at 1948 prices.
[55] Sales to personal consumers at 1948 prices.

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ORDER XVI.—OTHER MANUFACTURING INDUSTRIES

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
190.	Rubber	Consumption of rubber for making:	Tons					
		Aero covers		0·43	0·19	0·20	0·31	0·23
		Giant covers; horse-drawn vehicle covers; tank tyres; solid cushion tyres		9·14	9·76	13·30	12·49	14·51
		Car covers; motor cycle covers; aero tubes; motor cycle tubes		3·85	4·32	5·50	4·64	6·24
		Cycle covers		0·25	0·31	0·40	0·42	0·45
		Giant tubes; horse-drawn vehicle tubes		0·65	0·85	1·00	0·81	0·93
		Car tubes		0·46	0·61	0·70	0·52	0·72
		Cycle tubes; repair materials		0·41	0·54	0·50	0·47	0·64
		Belting		3·76	4·74	5·80	5·03	6·37
		Ebonite		0·52	0·63	0·70	0·77	0·88
		Hose		1·10	1·52	1·90	1·83	1·95
		Proofing		0·22	0·27	0·30	0·30	0·35
		Surgicals and thread		0·40	0·64	0·70	0·58	0·66
		Sponge		0·08	0·56	0·80	0·99	1·45
		Other miscellaneous		8·73	13·24	18·20	18·52	21·42
		Adults' rubber footwear	Pr. pairs	0·77	1·35	2·00	2·35	2·09
		Children's and other rubber footwear	,,	1·89	2·46	3·60	4·52	5·14
		Total: 190		32·66	41·99	55·60	54·55	64·03
191.	Linoleum, leather cloth, etc.	Linoleum	Pr. sq. yds.	4·02	4·41	6·30	7·58	7·52
		Felt base	,,	2·02	2·39	3·00	3·91	4·25
		Total: 191		6·04	6·80	9·30	11·49	11·77
192.	Brushes and brooms	Household brushes	Pr. number	2·00	2·03	2·10	1·96	1·96
		Tooth brushes	,,	0·61	0·55	0·40	1·85	2·44
		Shaving and other toilet brushes	,,	0·89	1·00	1·10		
		Paint brushes	,,	2·73	2·96	2·90	2·92	2·63
		Total: 192		6·23	6·54	6·50	6·73	7·03
193.	Toys, games and sports requisites	Toys and games	Pr. value deflated[56]	8·58	8·58	8·20	9·54	10·06
		Sports goods	,, ,,	1·78	2·51	2·80	3·62	3·35
		Total: 193		10·36	11·09	11·00	13·16	13·41

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ORDER XVI.—OTHER MANUFACTURING INDUSTRIES (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
194.	Miscellaneous stationers' goods	Fountain pens	Pr. number	0·91	1·40	2·30	2·88	3·25
		Pencils (graphite, drawing and coloured)	,,	0·89	0·95	1·10	1·16	1·28
		Total: 194		1·80	2·35	3·40	4·04	4·53
195.	Production and printing of cinematograph films	Films:	Registrations. Feet					
		Less than 3,000 ft.		1·75	2·31	2·40	2·43	2·21
		3,000 ft. to 6,000 ft.		1·34	1·44	2·50	1·12	1·07
		Over 6,000 ft.		8·58	9·68	15·10	16·75	14·12
		Total: 195		11·67	13·43	20·00	20·30	17·40
199.	Miscellaneous manufacturing industries	Synthetic resins	Cons. tons	d	d	d	d	d
		Acrylic sheet, casein, P.V.C.	,,	c	c	c	c	c
		Incandescent mantles	Pr. number	d	d	d	d	d
		Total: 199		9·46	10·08	10·30	9·22	12·68
	Total—Other Manufacturing Industries			78·22	92·28	116·10	119·49	130·85

[56] Deflated by hourly earnings, men, Min. List 193.

ORDER XVII.—BUILDING AND CONTRACTING

200.	Building	Building and civil engineering[57]		552·00	600·00	655·00	714·00	726·00
201.	Electric wiring and contracting							
202.	Civil engineering contracting (Also see notes)							
		Open-cast coal	Pr. tons	7·13	8·27	9·40	10·03	9·82
		Total: 200, 201, 202		559·13	608·27	664·40	724·03	735·82
	Total—Building and Contracting			559·13	608·27	664·40	724·03	735·82

[57] Deflated gross output *less* deflated cost of materials.

Weight.—The precise output to be included here is not readily determined by the Standard Industrial Classification. We have included here the erecting, but not the manufacturing work, of constructional engineers, and constructional work done by employees of gas, electricity and water supply undertakings and catchment and drainage boards. We have included here also an item definitely excluded by the Standard Industrial Classification, namely minor maintenance of highways by local authorities (about [30·0]).

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
		ORDER XVIII.—GAS, ELECTRICITY AND WATER						
210.	Gas	Gas available at gas works	G.B. therms	52·45	54·09	56·20	58·31	61·12
		Coke (at gas works)[58]	G.B. tons	15·29	15·16	16·70	17·07	14·64
		Total: 210		67·74	69·25	72·90	75·38	75·76
211.	Electricity	Electricity generated by authorized undertakings	G.B. kWh.	108·76	112·26	122·70	129·49	144·90
		Total: 211		108·76	112·26	122·70	129·49	144·90
212.	Water	Water undertakings	Assumed series	33·12	33·46	33·80	34·14	34·48
		Total: 212		33·12	33·46	33·80	34·14	34·48
	Total—Gas, Electricity and Water			209·62	214·97	229·40	239·01	255·14
		ORDER XIX.—TRANSPORT AND COMMUNICATION						
220.	Railways	British Railways, passengers:						
		Workmen's	Passenger miles	4·91	4·56	4·70	4·89	5·11
		Season	,, ,,	10·22	10·15	8·90	9·04	9·46
		Full fare	,, ,,	16·57	14·84	11·60	10·53	10·75
		Monthly return	,, ,,	66·90	50·82	46·50	39·40	35·08
		Excursion, etc.	,, ,,	0·00	1·59	4·30	9·31	12·09
		Others	,, ,,	35·55	20·76	16·70	15·24	13·97
		London Transport	,, ,,	6·75	6·56	7·50	7·47	7·53
		British Railways, freight:						
		Merchandise and livestock	Ton miles	66·42	60·03	62·80	62·47	62·54
		Minerals	,,	19·48	18·76	21·60	21·88	22·03
		Coal and coke	,,	45·80	47·99	49·60	51·48	52·67
		Parcels receipts	Value deflated[59]	17·00	17·00	16·50	16·30	17·33
		Sum of series for letters posted and parcels handled (*for* mail receipts)		5·16	5·25	5·20	5·25	5·32
		Total: 220		294·76	258·31	255·90	253·26	253·88

[58] Excludes coke used for heating retorts at gas works.

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ORDER XIX.—TRANSPORT AND COMMUNICATION (*continued*)

Standard Industrial Classification (Minimum List)		*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)*				
Number	*Heading*			1946	1947	1948	1949	1950
221.	Tramway and omnibus service	Road passenger services[60]	See notes	158·85	165·94	178·00	183·67	190·76
222.	Other road passenger transport							
		Total: 221 + 222		158·85	165·94	178·00	183·67	190·76
223.	Goods transport by road (Together with *all* "C"-licence transport (classified by SIC to trade of owner))	Goods transport by road[61]	Index	230·00	266·22	278·00	292·44	299·11
		Total: 223		230·00	266·22	278·00	292·44	299·11
(Not classified)		Cars	Licences current	16·31	17·93	18·50	19·68	20·89
		Motor cycles	,, ,,	1·24	1·43	1·50	1·74	2·01
		(*For* depreciation of roads by private users)						
		Total: not classified		17·55	19·36	20·00	21·42	22·90
224.	Sea transport	Carriers on canals	Net ton miles	0·70	0·75	0·80	0·80	0·82
225.	Port, river and canal transport	Ocean-going dry cargo and passenger ships	Active gross tonnage	109·80	105·92	103·00	108·83	111·75
226.	Harbour, dock, canal, conservancy, etc., service (Also 260 (part), Government services to shipping [+1·4])	U.K.–flag tankers	Do.	14·08	16·89	21·40	22·53	24·78
		Coasting trade arrivals and departures, all flags, with cargo and in ballast	Net tons	4·13	4·57	5·00	5·35	5·70
		Total entrances and clearances, all flags and trades (*for* port services)	,,	42·86	50·08	60·00	65·65	68·95
		Total: 224 + 225 + 226		171·57	178·21	190·20	203·16	212·00
227.	Air transport (Also 260 (part), Ministry of Civil Aviation, [+1·0])	U.K. Airways:						
		Passenger-miles (revenue)		7·19	8·74	11·00	12·19	15·74
		Mail	Ton miles	3·25	3·81	4·60	4·93	5·62
		Freight	,, ,,	1·16	1·51	2·30	2·69	3·25

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ORDER XIX. TRANSPORT AND COMMUNICATION (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at* 1948 *Prices* (£*mn.*) 1946	1947	1948	1949	1950
227. (continued)		Air Charter Association members[62]	Aircraft miles flown	1·63	4·67	7·00	7·00	7·00
		Total flights between U.K. and abroad plus twice internal stage flights (*for* aerodromes)	Number	2·75	4·35	3·60	3·84	4·07
		Total: 227		15·98	23·08	28·50	30·65	35·68
228.	Postal, telegraph and wireless communication	Letters posted	Number	40·75	42·45	45·00	47·55	48·68
		Parcels handled	,,	20·81	21·16	20·90	21·07	21·34
		Money orders handled and postal orders issued	,,	2·10	2·54	2·70	2·86	2·93
		Telegrams, number handled:						
		Inland	,,	6·29	5·84	5·30	5·10	5·18
		Foreign	,,	2·60	2·62	2·60	2·60	2·60
		Local telephone calls	,,	26·92	28·75	31·00	31·21	31·64
		Trunk telephone calls	,,	19·22	20·45	21·40	22·25	22·73
		Telegrams handled by cable companies	,,	4·76	4·80	5·00	4·98	5·04
		Total: 228		123·45	128·61	133·90	137·62	140·14
238.	Other transport and communication	(Transferred to 220, 223, 224 and 227)						
239.	Storage (part transferred to Distribution [— 5·0])	Spirits and wines in bond (*for* maturing of whisky, etc.)	Galls.	4·49	4·45	5·00	5·80	6·19
		Total: 239		4·49	4·45	5·00	5·80	6·19
	Total—Transport and Communication			1,016·65	1,044·18	1,089·50	1,128·02	1,160·66

[59] Deflated by price index based on rates charged.
[60] Personal and business expenditure at 1948 prices.
[61] Index based on numbers of vehicles with carriers' licences, weighted according to estimated net output of different categories and adjusted by a "degree of utilization" factor.
[62] Estimated.

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Order XX.—Distributive Trades[63]

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
240.	Dealing in coal, builders' materials, grain and agricultural supplies (wholesale or retail)[63]	Domestic coal	G.B. Cons. tons	26·96	27·27	27·50	26·73	27·96
		Northern Ireland coal shipments	Tons	1·67	1·67	1·60	1·67	1·67
		Engineering, coal for	G.B. Cons. tons	0·85	0·73	0·80	0·82	0·87
		Iron and steel, coal for	G.B. ,,	1·10	1·00	1·00	0·96	0·95
		Other industries and miscellaneous, coal for	G.B. Cons. tons	11·63	11·32	12·10	12·44	12·88
		Coastwise bunkers and bunkers oversea	Tons	0·90	0·86	1·00	0·94	0·78
		Index of output of building materials		c	c	c	c	c
		Farmers' purchases of feeding stuffs and fertilizers		c	c	c	c	c
		Total: 240		66·65	69·16	74·00	77·08	81·79
241.	Dealing in other industrial materials and machinery	Iron and steel scrap bought	Tons	5·56	5·30	7·00	7·94	8·32
		Non-ferrous metals[64]	Cons. tons	0·92	1·10	1·00	1·02	1·17
		Machinery, Home market[65]	Del. value deflated[66]	11·39	13·58	16·00	15·81	16·30
		Machinery: Ministry of Supply, sale of surplus stores	Value deflated[66]	12·53	8·83	4·30	2·09	0·97
		Softwood	Cons. standards	5·84	5·29	6·00	6·21	5·57
		Hardwood	Cons. cu. ft.	3·04	2·81	3·00	3·55	4·74
		Constructional plywood	Cons. sq. ft.	1·28	1·09	1·00	1·07	1·41
		Heavy leather	Cons. tons	4·41	4·73	4·70	4·59	4·21
		Light leather	Cons. sq. ft.	2·10	2·30	2·30	2·34	2·56
		Raw cotton	Cons. tons	0·93	0·94	1·10	1·12	1·16
		Raw wool—clean	Cons. lbs.	0·83	0·95	1·10	1·12	1·15
		Woven wool fabrics	Del. sq. yds.	7·35	7·65	8·80	9·31	9·54
		Woven cotton cloth and rayon, nylon and mixtures	Pr. lin. yds.	29·22	29·80	36·00	38·38	41·88
		Waste paper and rags	Cons. tons	3·29	3·37	4·00	3·98	4·43
		Sulphuric acid	Pr. tons	0·86	0·86	1·00	1·07	1·16
		Synthetic dyestuffs	Pr. lbs.	c	c	c	c	c
		Rubber (including reclaimed)	Cons. tons	d	d	d	d	d
		Total: 241		90·99	90·20	99·30	101·37	106·72

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ORDER XX.—DISTRIBUTIVE TRADES (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at* 1948 *Prices* (£mn.) 1946	1947	1948	1949	1950
242.	Wholesale distribution of food and drink *and*	Food distribution to households[67]	Index	381·17	407·31	414·20	424·42	438·01
243.	Retail distribution of food and drink (excluding catering) (Also 260 (part), Ministry of Food [+ 13·6])	Expenditure on food at catering establishments (*for* distribution to caterers)[68]	See notes	36·08	40·03	39·40	41·46	42·09
		Total: 242, 243		417·25	447·34	453·60	465·88	480·10
244.	Wholesale distribution of non-food goods	Volume of U.K. exports	Index	18·56	20·39	25·90	28·55	33·04
245.	Retail distribution of non-food goods	Volume of U.K. re-exports	,,	1·07	1·18	1·10	1·00	1·15
246.	Retail distribution of confectionery, tobacco and newspapers (Also 81(2) garages [+ 45·0])	Cigarettes[71]	See notes	75·56	66·14	63·00	60·94	62·31
		Other tobacco[71]	,,	9·62	8·52	9·00	8·93	8·38
		Fuel, other than coal, gas and electricity[71]	,,	6·79	7·21	7·00	7·00	7·42
		Furniture and furnishings (including radios, etc.)[71]	,,	53·95	69·74	75·00	89·47	101·84
		Hardware[71]	,,	43·84	49·28	48·00	48·32	48·96
		Other household goods[71]	,,	14·46	15·04	16·00	18·51	19·66
		Footwear[71]	,,	18·88	22·60	26·00	27·08	27·70
		Other clothing[71]	,,	150·91	167·39	182·00	195·02	203·52
		Books[71]	,,	9·09	9·39	10·00	9·70	10·30
		Newspapers[71]	,,	19·07	21·27	22·00	23·83	23·83
		Magazines[71]	,,	9·00	10·00	11·00	13·00	15·33
		Cars. Registrations of new vehicles:						
		< 1,600 c.c.	Number	3·96	4·46	2·30	3·80	2·64
		1,600 to 2,200 c.c.	,,	0·93	1·59	2·40	1·84	1·70
		> 2,200 c.c.	,,	0·28	0·46	1·10	2·20	3·35
		Goods vehicles. Registrations of new vehicles:						
		< 15 cwt.	,,	1·11	1·39	1·00	1·26	1·10
		15 cwt. and over	,,	5·31	6·01	5·50	4·87	4·19
		Motor cycles and tricycles. New Registrations	,,	0·92	0·79	0·90	1·09	1·61
		Dealing in petrol, secondhand vehicles, motor parts and accessories (confidential series combined to avoid disclosure)[69]		47·43	53·29	53·00	59·47	66·87
		Flowers and garden seeds[71]	See notes	13·00	15·00	19·00	20·00	20·50
		Stationery (private)[71]	,,	11·05	14·49	14·00	13·75	12·77
		Stationery (business)[70]	,,	3·28	4·00	4·00	4·00	4·00
		Chemists' wares[71]	,,	41·53	43·37	41·00	44·42	46·26
		National Health prescriptions[72]	Number	2·77	2·77	6·00	8·70	9·99

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Order XX.—Distributive Trades (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
244, 245, 246 (continued)		Bicycles and accessories[73]	See notes	4·00	4·42	4·00	4·21	4·42
		Travel goods, fancy goods and toys[73]	,,	22·98	33·23	36·00	36·28	34·62
		Secondhand furniture[73]	,,	18·00	12·00	6·00	3·60	3·00
		Total: 244, 245, 246		607·35	665·42	692·20	740·84	780·46
Total—Distributive Trades				1,182·24	1,272·12	1,319·10	1,385·17	1,449·07

[63] Less Agricultural Dealers [— 6·0]. Including 239 Storage (part) [+ 5·0]; weight spread over whole Order.
[64] Including secondary aluminium, scrap copper, zinc and lead.
[65] Including agricultural machinery, portable power tools, engineers' small tools, internal combustion engines, pumps and pumping plant, rotating electrical machines, refrigerating machinery, and office machinery.
[66] Deflated by average of indices of hourly earnings for men in mechanical and electrical engineering and of cost of materials.
[67] The index is based on 36 consumption series weighted by estimated distributive margins in 1948.
[68] Personal and business expenditure at 1948 prices.
[69] Includes head offices of oil companies operating overseas.
[70] Business expenditure at 1948 prices.
[71] Personal expenditure at 1948 prices.
[72] 1946, 1947—assumed series.
[73] Personal expenditure at 1948 prices.

Order XXI.—Insurance, Banking and Finance

250. Insurance, banking and finance (1) Insurance	Life Insurance (Ordinary Business):						
	New policies, sum assured	Value deflated[74]	4·41	5·43	5·00	4·92	4·81
	Income and outgoings	,, ,,	11·69	12·05	12·00	12·47	12·74
	Life and annuity funds (*for* management of funds)	,, ,,	3·08	3·04	3·00	3·11	3·26
	Life Insurance (Industrial Business):						
	Income and outgoings	,, ,,	17·99	18·06	18·00	18·55	19·25
	Funds (*for* management of funds)	,, ,,	2·03	2·03	2·00	2·06	2·13
	Accident Insurance:						
	Premium income	,, ,,	1·93	2·22	2·30	2·51	2·65
	Employers' Liability:						
	Premium income	Value deflated[75]	5·51	6·37	4·00	1·90	2·17
	Fire Insurance:						
	Net rent of land and buildings	Value	15·66	16·30	16·80	17·26	17·73
	Premiums (*for* U.K. administration of foreign business)	Value deflated[76]	7·53	8·01	8·40	9·29	9·99
	Marine Insurance:						
	World active tonnage	Assumed series	9·80	9·80	10·00	10·20	10·50

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ORDER XXI.—INSURANCE, BANKING AND FINANCE (*continued*)

Standard Industrial Classification Minimum List Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
250. (1) (continued)		Motor Vehicle Insurance:						
		Cars	Licences current	10·30	11·32	11·50	12·42	13·19
		"C" licence vehicles	,, ,,	1·53	1·92	2·40	2·84	3·21
		Motor cycles	,, ,,	1·41	1·62	1·70	1·98	2·27
		Others	,, ,,	5·12	5·89	6·40	6·66	6·57
		Total: 250 (1)		97·99	104·06	103·50	106·17	110·47
	(2) Banking and bill-discounting (A value of output is here imputed to banking, the value of services rendered free to business being deducted in the Summary table)	Commercial Banks:						
		Stamp duty on cheques	Value deflated[77]	46·04	58·49	56·00	54·35	55·50
		Advances (London clearing banks)	Value deflated[78]	7·84	9·10	10·10	10·76	11·69
		Other assets[79] (London clearing banks)	Value deflated[78]	4·06	4·16	3·90	3·74	3·53
		G.P.O. Savings Banks:						
		Deposits, withdrawals, savings certificates issued and repaid	Number	11·94	10·44	9·30	8·55	8·30
		Amounts outstanding, P.O. savings banks and National Savings Certificates	Value deflated[80]	2·33	2·22	2·10	2·06	2·00
		Trustee Savings Banks:						
		Amount remaining invested	Value deflated[80]	2·44	2·48	2·50	2·60	2·69
		Total: 250 (2)		74·65	86·89	83·90	82·06	83·71
	(3) Finance	Markings, London Stock Exchange (*for* Stockbrokers)	Number	21·61	19·85	15·00	13·09	14·05
		New capital issues	Value deflated[81]	6·28	6·60	7·00	5·32	7·06
		Investment Trusts[82]	Assumed series	1·00	1·00	1·00	1·00	1·00
		Building Societies:						
		New advances on mortgage	Value deflated[83]	2·64	2·96	3·00	3·07	3·16
		Withdrawals—shares and deposits	Value defiated[84]	1·84	1·90	2·00	2·25	2·39
		Balances due on mortgages	,, ,,	0·88	0·94	1·00	1·11	1·16
		Total: 250 (3)		34·25	33·25	29·00	25·84	28·82
	(4) Property owning and managing, etc.	Rents, etc. (*for* house ownership and occupation and rent collection)[85]	See notes	425·22	433·37	443·00	451·15	457·82

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Order XXI.—Insurance, Banking and Finance (*continued*)

Standard Industrial Classification (Minimum List)		*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)*				
Number	*Heading*			1946	1947	1948	1949	1950
250. (4) (continued)		Stamp duties on land, houses and leases (*for* property transfers, agency, etc.)[86]	Value deflated[86]	10·94	10·52	10·00	9·74	9·34
		Grants of probate (*for* valuations for death duty)	Number	1·07	1·06	1·00	1·06	1·08
		Total: 250 (4)		437·23	444·95	454·00	461·95	468·24
Total—Insurance, Banking and Finance				644·12	669·15	670·40	676·02	691·24

[74] Deflator used throughout this order unless otherwise stated—price index obtained from the National Income White Paper by dividing personal expenditure at current prices by personal expenditure at 1948 prices.
[75] Deflated by earnings, all operatives, M. of L. enquiries.
[76] Deflated by assumed series based on U.S. construction cost index.
[77] Deflated by rate of duty (constant).
[78] See note 74.
[79] Including call money, bills discounted, treasury deposit receipts, and investments.
[80] See note 74.
[81] Deflated by average of building cost and wholesale price indices.
[82] Based on private information.
[83] Deflated by index of vacant possession prices.
[84] See note 74.
[85] Personal expenditure at 1948 prices.
[86] Stamp duties inflated by rates of duty to give value of property and deflated by index of vacant possession prices.

Order XXII.—Public Administration and Defence

260. National Government Service (1) to (5): Defence[87]	Armed Forces	Pay and allowances deflated[88]	599	353	250	232	233
	Civilian employees in defence departments	Wages and salaries deflated[88]	91	83	76	76	73
	Works services abroad	Cost deflated[89]	20	13	9	9	10
	Total: 260 (1) to (5)		710	449	335	317	316
260. National Government Service (6) Other	Prisons—receptions	Number	0·84	0·90	1·00	0·88	0·91
	inmates	,,	1·23	1·31	1·50	1·59	1·63
	Courts of Justice[90]	Index	5·04	5·93	6·40	6·26	6·40
	Public Trustee	Fees deflated[91]	0·23	0·25	0·30	0·29	0·29
	National Debt management[92]	Assumed series	2·00	1·50	1·30	1·20	1·15
	Ministry of Labour:						
	Trainees in Government training centres[93]	Numbers	0·46	0·28	0·10	0·09	0·06
	Registrations for National Service	,,	0·14	0·13	0·10	0·13	0·12
	Beneficiaries—Ministry of Pensions	Number	3·89	4·50	4·50	4·50	4·50
	Health Insurance:						
	Insured	Numbers	4·15	4·06	4·50	4·83	4·83
	Sickness and maternity beneficiaries	,,	4·53	4·57	4·50	5·09	5·21
(*Less*—							
Ministry of Agriculture [10·0]							
Government services to shipping [1·4]							
Ministry of Civil Aviation [1·0]							
Ministry of Food [13·6]							
Miscellaneous services to industry [29·2])							

ORDER XXII.—PUBLIC ADMINISTRATION AND DEFENCE (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
260 (6) (continued)		Unemployment Insurance:						
		Insured	Numbers	1·01	1·03	1·20	1·38	1·39
		Unemployed. Monthly average	,,	4·82	6·05	4·00	4·01	4·05
		Pensions:						
		Insured	,,	3·92	3·87	4·00	4·05	4·05
		Pensions in issue	,,	0·94	0·97	1·00	1·02	1·04
		Claims	,,	1·06	1·02	1·00	0·99	0·99
		Family Allowances:						
		In payment	,,	0·18	0·47	0·50	0·53	0·54
		Claims dealt with	,,	8·39	1·29	1·00	0·98	0·93
		Industrial Injuries:						
		Insured	,,	0·00	0·00	0·30	0·60	0·60
		Claims	,,	0·00	0·00	1·50	3·53	3·53
		National Assistance:						
		Number of beneficiaries (other than supplementation of benefits above)[94]	,,	1·36	1·19	1·30	1·84	1·75
		Ministry of Works maintenance functions not included in building and civil engineering:						
		Non-building industrial staff (*for* care of public buildings)	Number	2·19	2·25	3·00	3·15	2·74
		Value added in building and civil engineering at constant prices (*for* services to industry)	Index	5·90	6·41	7·00	7·63	7·76
		All other National Government services not specified above or transferred elsewhere	Wages and salaries deflated[95]	78·05	95·22	101·70	107·22	111·91
		Total: 260 (6) (part)		130·33	143·20	151·70	161·79	166·38
265. Local Government Service (part) (*Less* minor work on highways and bridges [— 30·0])		Police—regulars and auxiliaries	G.B. Number	34·88	35·21	36·30	36·78	36·97
		Fire service—wholetime strength	G.B. ,,	12·03	10·82	8·90	8·88	8·88
		Public libraries and museums[96]	E. and W. Index	4·29	4·82	5·30	5·46	5·57
		Sewers and sewage disposal[97]	See notes	12·99	13·20	13·50	13·68	13·88
		Collection and disposal of refuse[98]	E. and W. Index	12·83	13·96	14·10	14·24	14·24
		Baths, etc.[99]	,,	3·61	3·84	3·80	3·80	3·80
		Parks, etc.[100]	,,	6·02	6·79	7·00	7·14	7·28
		Stock of local authority houses (*for* housing—administration and depreciation)	G.B. Number	14·17	15·35	17·00	18·78	20·35

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ORDER XXII.—PUBLIC ADMINISTRATION AND DEFENCE (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
265 (continued)		Allotments and small-holdings	Assumed series	1·30	1·30	1·30	1·30	1·30
		Land drainage, sea defences and river conservancy	,, ,,	4·43	4·66	4·70	4·74	4·79
		Scavenging[101]	See notes	5·02	5·41	5·60	5·65	5·65
		Public lighting—weighted average of gas and electricity used	Index	2·00	1·47	2·10	2·14	2·16
		Rate collection. Total collected, deflated[102]	Value deflated[102]	2·44	2·60	2·50	2·51	2·54
		Valuation for rating	Assumed series	1·00	1·00	1·00	1·00	1·00
		Cemeteries[103]	See notes	2·04	2·17	2·10	2·19	2·20
		Town and Country Planning	Assumed series	0·90	1·35	1·80	2·25	3·15
		Emergency services—civil defence and accommodation	,, ,,	21·84	19·32	16·80	15·96	15·96
		Employment, all local government service (*for* general administration)	Numbers	52·31	57·44	60·00	61·14	62·52
		Total: 265 (part)		194·10	200·71	203·80	207·64	212·24
Total—Public Administration and Defence				1034·43	792·91	690·50	686·43	694·62

[87] Decimals omitted, to emphasize approximate nature of series.
[88] Deflated by index based on rates of pay.
[89] Deflated by assumed price series.
[90] Index of number of cases tried (weighted average of 8 types).
[91] Deflated by assumed price series.
[92] Based on management expenses.
[93] The placement service of the Ministry of Labour is treated as a free service to industry.
[94] Public assistance and agency services by local authorities included.
[95] Deflated by index based on rates of pay.
[96] Based on cost deflated by wage rates and book prices.
[97] Series based on total population and industrial activity.
[98], [99], [100] Based on cost deflated by wage rates.
[101] Based on length of urban roads and assumed factor for cleanliness.
[102] Deflator see note 74.
[103] Based on number of deaths and assumed factor for maintenance, etc.

ORDER XXIII.—PROFESSIONAL SERVICES

270. Accountancy	Weight, in principle, added to weights of trades receiving accountancy services							
271. Education	Pupils on registers of primary, nursery and special schools[104]		Numbers	51·93	51·47	53·00	53·77	54·56
	Teachers in primary schools	E.+W.	,,	50·05	51·74	53·00	53·42	53·84
	Pupils on registers of secondary and direct grant grammar schools		,,	35·19	37·02	42·00	44·60	46·74
	Teachers in secondary schools	E.+W.	,,	34·70	38·96	42·00	45·65	47·48

ORDER XXIII.—PROFESSIONAL SERVICES (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
271 (continued)		Independent schools	Assumed series	17·14	18·57	20·00	21·42	22·86
		Further education establishments	E.+W. Student hours	3·87	4·19	5·00	5·81	6·29
		Other adult education, part-time	E.+W. Student terms	0·86	0·93	1·00	1·05	1·10
		Teachers in training	Number	1·27	1·78	2·00	1·97	1·89
		Students at Universities	G.B. ,,	14·03	17·75	20·00	20·83	21·34
		Children in approved schools	G.B. ,,	1·16	1·02	1·00	0·98	0·98
		Total: 271		210·20	223·43	239·00	249·50	257·08
272. Law		Courts (*for* lawyers' court business)[105]	Index	10·48	12·33	13·30	13·02	13·31
		Grants of probate (*for* probate business)	Number	8·56	8·44	8·00	8·46	8·60
		Stamp duties (*for* conveyancing)[106]	Value deflated	13·13	12·62	12·00	11·68	11·21
		Total: 272		32·17	33·39	33·30	33·16	33·12
273. Medical and Dental Services		National Health Service hospitals—occupied beds[107]	G.B. Number	63·03	64·51	66·00	67·49	68·53
		Mid-year employment at all hospitals and similar institutions:						
		Nursing staff	G.B. ,,	36·12	33·63	35·00	38·01	40·43
		Domestic staff	G.B. ,,	33·18	34·05	35·00	36·50	38·69
		Doctors in general practice	,,	47·98	49·49	50·50	50·70	51·00
		Births (*for* local authority maternity services, etc.)	,,	13·67	14·77	13·00	12·27	11·66
		Dental payments, including estimate for dentists not in N.H.S.[108]	E.+W. Index (value deflated)	18·75	21·88	25·00	37·32	40·77
		Sight tests given[108]	E.+W. Number	6·43	7·14	10·00	11·25	8·84
		Children on registers of maintained and assisted schools (*for* school medical services)	,,	7·84	7·97	8·50	8·63	8·76
		Total: 273		227·00	233·44	243·00	262·17	268·68

ORDER XXIII.—PROFESSIONAL SERVICES (*continued*)

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ORDER XXIII.—PROFESSIONAL SERVICES (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
274.	Religion	Religion[109]	Index	20·00	20·00	20·00	20·00	20·00
		Total: 274		20·00	20·00	20·00	20·00	20·00
279.	Other professional and business services (part)	Trade unionists (*for* trade and professional associations, part)	Number	4·96	5·38	5·50	5·56	5·56
		Books (*for* authors, etc.)[110]	See notes	2·73	2·82	3·00	2·91	3·09
		Index for Order XVII (*for* architects)	—	8·43	9·16	10·00	10·90	11·08
		Total: 279 (part)		16·12	17·36	18·50	19·37	19·73
279.	Other professional and business services (part)	Weights are, in principle, added to weights of the trades receiving the services						
	Total—Professional Services			505·49	527·62	553·80	584·20	598·61

[104] Maintained, grant-aided and efficient schools.
[105] Index of numbers of cases tried (see 260 (6)).
[106] Stamp duties inflated by rates of duty to give value of property, and deflated by index of vacant possession prices.
[107] Includes corresponding services before inception of N.H.S.
[108] Assumed series before 1948.
[109] Weighted index of numbers of ministers and paid church officers of different denominations.
[110] Personal expenditure on books at 1948 prices.

ORDER XXIV.—MISCELLANEOUS SERVICES

280.	Theatres, cinemas, music halls, concerts, etc.	Cinemas—expenditure[111]	See notes	43·21	38·57	40·00	37·50	38·21
281.	Sport, other recreations and betting	Other taxed entertainment—expenditure[111]	,, ,,	17·59	17·59	18·00	17·59	15·95
		Other non-taxed entertainment—expenditure[111]	,, ,,	3·89	4·44	5·00	5·56	6·67
		Betting services—expenditure[111]	,, ,,	30·63	29·77	30·00	26·89	25·80
		Broadcasting:						
		Wireless licences current	Number	2·84	2·89	3·00	3·16	3·16
		Home sound programmes	Hours	2·75	2·71	3·00	3·07	3·07
		Television licences current	Number	0·02	0·07	0·20	0·54	1·48
		Television programmes	Hours	0·10	0·16	0·20	0·20	0·26
		Overseas programmes	Transmitter hours	2·75	2·45	2·00	2·06	2·01
		Total: 280 + 281		103·78	98·65	101·40	96·57	96·61
285.	Catering, hotels, etc.	Catering and hotels—expenditure[112]	See notes	145·97	146·67	150·00	147·94	141·13
		Beer expenditure[113]	,, ,,	94·62	89·65	87·00	84·18	86·33

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ORDER XXIV.—MISCELLANEOUS SERVICES (*continued*)

Standard Industrial Classification (Minimum List) Number	Heading	*Indicator*		*Estimated Value Added at 1948 Prices (£mn.)* 1946	1947	1948	1949	1950
285 (continued)		Wines, spirits etc.—expenditure[114]	See notes	52·65	58·45	58·00	53·98	58·67
		Total: 285		293·24	294·77	295·00	286·10	286·13
286.	Laundries	Laundries—expenditure[115]	See notes	26·67	32·28	40·00	41·40	40·70
		Total: 286		26·67	32·28	40·00	41·40	40·70
287.	Dry cleaning, job dyeing, carpet beating, etc.	Dyeing and cleaning—expenditure[116]	See notes	8·56	9·78	11·00	11·00	10·39
		Total: 287		8·56	9·78	11·00	11·00	10·39
288.	Hairdressing and manicure	Hairdressing—expenditure[117]	See notes	31·41	33·46	35·00	32·44	32·44
		Total: 288		31·41	33·46	35·00	32·44	32·44
290.	Private domestic service (resident)	Private domestic service—expenditure[118]	See notes	92·08	102·32	108·00	100·04	94·36
291.	Private domestic service (non-resident)							
		Total: 290 + 291		92·08	102·32	108·00	100·04	94·36
299.	Other services	Deaths (*for* funeral direction)	Number	12·59	13·21	12·00	12·97	12·97
		Voluntary social services[119]	Assumed series	9·40	9·20	9·00	8·80	8·70
		Political organizations—employment[120]	Number	0·48	0·48	0·50	0·60	0·57
		Chimney sweeping and window cleaning[121]	See notes	7·56	8·50	8·50	9·44	10·38
		Other services[122]	Assumed series	54·00	57·00	60·00	61·20	62·40
		Total: 299		84·03	88·39	90·00	93·01	95·02
Total—Miscellaneous Services				639·77	659·65	680·40	660·56	655·65

[111] Personal expenditure at 1948 prices.
[112] Personal and business expenditure at 1948 prices.
[113] Personal expenditure at 1948 prices.
[114] Personal expenditure on wines and spirits, plus business expenditure on all alcoholic drinks at 1948 prices.
[115] Personal expenditure at 1948 prices.
[116] Personal expenditure at 1948 prices.
[117] Personal expenditure at 1948 prices.
[118] Personal expenditure at 1948 prices.
[119] Based on professional advice.
[120] No productivity adjustment.
[121] Personal expenditure at 1948 prices.
[122] Includes an allowance for the "services" of prostitutes.

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MUNITIONS[123]

Standard Industrial Classification (Minimum List) — *Number*	*Heading*	*Indicator*	*Estimated Value Added at Current Prices* (£mn.) 1946	1947	1948	1949	1950
ORDER VI:							
50.	Shipbuilding and ship repairing (part)	*Admiralty:*					
51.	Marine engineering (part)	Cost of personnel employed on dockyard work plus half cost of contract work less half cost of purchases through the Ministry of Supply	39·8	33·6	29·6	35·7	37·0
57.	Ordnance and small arms (part)	Cost of personnel employed on naval armaments plus half cost of guns, torpedoes, etc., less half cost of purchases through Ministry of Supply	7·0	6·6	5·7	7·7	6·9
		Total: Admiralty	46·8	40·2	35·3	43·4	43·9
ORDER IV:							
33.	Explosives and fireworks (part)	*Ministry of Supply and Royal Ordnance Factories:*					
		Half cost of guns, small arms and ammunition	21·5	5·5	2·5	5·8	10·0
ORDER VI:		Half cost of defence service work at R.O.F.'s plus half cost of other services for Ministry of Supply establishments	11·4	11·4	10·0	12·5	15·8
57.	Ordnance and small arms (part)	Half cost of mechanical transport	8·5	1·8	15·0	18·7	19·4
		Half cost of military aircraft, spares and engines	95·7	35·4	46·6	46·0	49·4
ORDER VII:		Less for expenditure on work not done this year	*−20·0*	—	—	—	—
80.	Manufacture of motor vehicles and cycles (part)						
82.	Manufacture and repair of aircraft (part)	Total: Ministry of Supply	117·1	54·1	74·1	83·0	94·6
83.	Manufacture of parts and accessories for motor vehicles and aircraft (part)						
		Total at current prices	163·9	94·3	109·4	126·4	138·5
			Estimated Value Added at 1948 *Prices* (£mn.)[124]				
	Total—Munitions		192·6	99·0	109·4	123·0	125·5

[123] Weights transferred from: Order IV, [1·3]; Order VI, [46·5]; Order VII, [61·6]. Figures very approximate.

[124] Deflated by average of index of hourly earnings for men in mechanical engineering and index of cost of materials used.

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SUMMARY TABLE

S.I.C. Order most nearly corresponding	*Estimated Value Added at 1948 Prices (£mn.)*					*Weights per 1,000*
	1946	1947	1948	1949	1950	
1. Agriculture, forestry, fishing	549·27	554·03	608·00	646·51	591·76	57
2. Mining and quarrying	369·12	381·16	405·50	416·77	421·55	38
3. Treatment of non-metalliferous mining products other than coal	112·16	126·35	144·00	152·25	157·59	14
4 (part). Chemicals and allied trades	225·80	231·89	261·20	282·30	319·05	25
5. Metal manufacture	258·87	276·02	308·40	320·09	340·56	29
6 (part). Engineering, shipbuilding and electrical goods	604·33	676·34	767·70	803·26	863·13	72
7 (part). Vehicles	276·96	312·20	335·80	379·29	429·03	32
8. Metal goods not elsewhere specified	196·24	212·87	218·20	230·79	234·55	20
9. Precision instruments, jewellery, etc.	60·35	66·58	66·90	72·82	75·90	6
10. Textiles	339·59	359·95	424·20	455·08	495·00	40
11. Leather, leather goods and fur	38·14	42·55	42·10	41·40	41·40	4
12. Clothing	190·56	202·70	211·00	228·25	234·89	20
13. Food, drink and tobacco	448·56	453·28	469·70	477·18	483·43	44
14. Manufactures of wood and cork	112·46	111·29	121·90	137·22	144·86	11
15. Paper and printing	192·90	205·28	214·00	253·51	294·32	20
16. Other manufacturing industries	78·22	92·28	116·10	119·49	130·85	11
17. Building and contracting	559·13	608·27	664·40	724·03	735·82	63
18. Gas, electricity and water	209·62	214·97	229·40	239·01	255·14	22
19. Transport and communication	1,016·65	1,044·18	1,089·50	1,128·02	1,160·66	103
20. Distributive trades	1,182·24	1,272·12	1,319·10	1,385·17	1,449·07	124
21. Insurance, banking and finance	644·12	669·15	670·40	676·02	691·24	63
22. Public administration and defence: Defence	710·00	449·00	335·00	317·00	316·00	32
The rest	324·43	343·91	355·50	369·43	378·62	33
23. Professional services	505·49	527·62	553·80	584·20	598·61	52
24. Miscellaneous services	639·77	659·65	680·40	660·56	655·65	64
4, 6, 7 (parts). Munitions	192·60	99·00	109·40	123·00	125·50	10
Less—						
Unallocated input of banking*	−81·34	−102·50	−100·00	−98·36	−101·03	−9
Real product of the United Kingdom	9,956·24	10,090·14	10,621·60	11,124·29	11,523·15	1,000
Manufacturing Industries (Orders 3 to 16, including munitions)	3,327·74	3,468·58	3,810·60	4,075·93	4,370·06	

* For value of banking services to industry, not deducted as input.

Index of Estimated Value Added (1948 = 100)

S.I.C. Order most nearly corresponding	1946	1947	1948	1949	1950
1. Agriculture, forestry, fishing	90·3	91·1	100·0	106·3	97·3
2. Mining and quarrying	91·0	94·0	100·0	102·8	104·0
3. Treatment of non-metalliferous mining products other than coal	77·9	87·7	100·0	105·7	109·4
4 (part). Chemicals and allied trades	86·4	88·8	100·0	108·1	122·1
5. Metal manufacture	83·9	89·5	100·0	103·8	110·4
6 (part). Engineering, shipbuilding and electrical goods	78·7	88·1	100·0	104·6	112·4
7 (part). Vehicles	82·5	93·0	100·0	113·0	127·8
8. Metal goods not elsewhere specified	89·9	97·6	100·0	105·8	107·5
9. Precision instruments, jewellery, etc.	90·2	99·5	100·0	108·8	113·5
10. Textiles	80·1	84·9	100·0	107·3	116·7
11. Leather, leather goods and fur	90·6	101·1	100·0	98·3	98·3
12. Clothing	90·3	96·1	100·0	108·2	111·3
13. Food, drink and tobacco	95·5	96·5	100·0	101·6	102·9
14. Manufactures of wood and cork	92·3	91·3	100·0	112·6	118·8
15. Paper and printing	90·1	95·9	100·0	118·5	137·5
16. Other manufacturing industries	67·4	79·5	100·0	102·9	112·7
17. Building and contracting	84·2	91·6	100·0	109·0	110·7
18. Gas, electricity and water	91·4	93·7	100·0	104·2	111·2
19. Transport and communication	93·3	95·8	100·0	103·5	106·5
20. Distributive trades	89·6	96·4	100·0	105·0	109·9
21. Insurance, banking and finance	96·1	99·8	100·0	100·8	103·1
22. Public administration and defence: Defence	211·9	134·0	100·0	94·6	94·3
The rest	91·3	96·7	100·0	103·9	106·5
23. Professional services	91·3	95·3	100·0	105·5	108·1
24. Miscellaneous services	94·0	97·0	100·0	97·1	96·4
4, 6, 7 (parts). Munitions	176·1	90·5	100·0	112·4	114·7
Index of real product of the United Kingdom	93·7	95·0	100·0	104·7	108·5
Index for manufacturing industries (Orders 3 to 16, including munitions)	87·3	91·0	100·0	107·0	114·7

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The Teaching of Statistics in Schools

I. Introduction

1. The Teaching of Statistics Committee appointed by the Council of the Royal Statistical Society has now followed up its report on the Teaching of Statistics in the Universities* by one on the Teaching of Statistics in Schools. The Council has considered the Committee's report on this subject and present their views in the following memorandum.

2. The membership of the Committee is as follows: Professor E. S. Pearson (Chairman), Professor R. G. D. Allen, Mr. B. C. Brookes, Mr. H. Campion, Sir William Elderton, Dr. C. Oswald George, Mr. R. F. George, Dr. D. Heron, Dr. J. O. Irwin, Dr. E. C. Rhodes, Mr. L. H. C. Tippett, Dr. J. Wishart, Mr. C. A. Moser (Honorary Secretary).

3. Information has been sought of a number of educational authorities, and comments have been asked of a number of teachers and other educationists on a preliminary draft of this memorandum. These requests for help have been generously met, and the resulting information and advice have materially affected the memorandum. We cordially express thanks to those who have helped in these ways.

4. In passing from teaching in universities to teaching in schools we are conscious not only of the function of the schools to prepare for the university, but also of the broad, educative value of what has been termed the statistical approach. We are confident that this approach and acquaintance with some elementary statistical techniques help the citizen to play a proper part in the everyday life of a democracy, and we therefore urge that the subject should be introduced into all secondary schools as part of the general education. In addition, statistics in its various branches is becoming increasingly important for many professions, and should have its place in the more specialist studies of the upper forms of secondary schools and in technical colleges. This is the thesis of the present memorandum.

5. The introduction of statistics into schools involves a number of detailed considerations, some of which are discussed in the memorandum, but not disposed of. Indeed, we are more concerned that suitable statistical knowledge and ways of thinking should be imparted and developed in the right spirit than that any particular syllabuses or forms of organization for the teaching should be adopted. It is for teachers and associated educationists to deal with these details, and we are primarily concerned to establish the case so as to give teachers the urge to deal with the details of application. We are aware that the introduction of statistics into schools is beset by many difficulties and raises many problems, particularly in these days when so many studies are competing for place in crowded time-tables. But we believe that if the case for statistics is examined on its intrinsic merits and is not prejudiced by the newness of the subject and lack of understanding, the difficulties will be overcome and statistics will find a proper place in the general and special curricula.

II. The Role of Statistics in General Education

6. The arguments for including any subject as a part of general education must relate to the purpose that education is held to serve, and for this memorandum the definition of purpose given by the Norwood Committee will be adopted:

> "to help each individual to realize the full powers of his personality—body, mind and spirit—in and through active membership of a society".†

The next few sections discuss what aspects of statistical studies contribute to the achievement of this purpose.

7. Perhaps the most fundamental result of a statistical training is that it encourages a habit of disciplined thinking about ordinary affairs in terms of *quantities*.

* *J.R. Statist. Soc.* (1947), vol. cx, p. 51.
† *Curriculum and Examinations in Secondary Schools.* H.M.S.O., 1941.

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Lord Kelvin has written:

> "When you can measure what you are speaking about and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind".

While we believe that qualitative knowledge is much more valuable than this quotation suggests, yet when, in addition, it can be correctly expressed quantitatively there is a gain, and it has been largely the business of statistics to make possible this development in many fields. In private and public life people have to speak and think about many things they cannot express in numbers, but it helps if they can at least recognize that these things often have a quantitative basis; and the confusion with which some controversies are conducted is evidence that present methods of education do not successfully foster this point of view.

8. The statistician is taught, and the citizen also should learn, to appraise figures critically, to appreciate their fallibility and limitations, and in particular to consider the effects of the errors with which such figures measure things. Figures are abstractions, and it requires some sophistication to remember, when interpreting them, all the background of circumstances in which they were obtained. It is common to adopt a precise definition of a quantity, such as the number of names on certain registers on a given day, and then give it a title, such as "unemployment", that has a broader meaning in ordinary speech. In a public opinion survey certain people are asked certain questions under certain conditions, and then the result is stated in the form that x per cent. of people prefer electric radiators to gas fires. Speeds achieved in record-breaking sporting trials are given to many decimal places, and one suspects that many people think that the accuracy of the result is limited by the patience of the computer or the capacity of the calculating machine rather than by the accuracy with which the distance and time of the run are observed. When figures are used naïvely, either discussion becomes long and confused, with the participants talking at cross-purposes, or people lose faith in figures and so deny themselves a valuable means of enlightenment. It is good if the citizen can get used to the idea that figures, although useful and even necessary, are seldom if ever to be taken at their face value.

9. In schools the naïve approach to figures is becoming outmoded, and it is not considered good practice that children should be led to accept entirely without question the data on which mathematical exercises are based, or to record, without considering their implications, the results of scientific exercises and experiments. Undoubtedly some data must be accepted as given, at least tentatively, if progress is to be made with the teaching of methods. A critical attitude to the figures supplied, however, should be encouraged and a good mark should go to the child whose comment on the answer to an artificial proportion problem regarding men building a wall was that so many men would get in one another's way. A typical school experiment in elementary physics is to determine the specific gravity of a substance heavier than water, e.g., glass in the form of a stopper. The pupil is usually carefully instructed in the laboratory procedure of weighing the stopper in air and "in water". After the weighings the result should not be merely recorded as: "the specific gravity of the glass stopper is 2·563". The results of different pupils should be compared and the implications of the variations be discussed. Whose result is "right"? What is the "true" specific gravity of glass? Does it vary from one stopper to another? What happens when the same pupil makes repeated determinations, (*a*) with the same stopper, and (*b*) with different stoppers? These and similar questions should be raised early in the pupils' minds, and answered, or they may never be asked. The development of a balanced and reflective outlook on figures is a slow process, and if it is not begun at school before the child's mind begins to crystallize, it may never take place.

10. Figures are much used to prove things, and every individual will be helped "to realize the full powers of his personality in and through active membership of a society" if he can achieve some facility in tracing the pattern of cause and effect underlying numerical data and in drawing rational conclusions. In the experimental sciences this is relatively easy, since the object of any experiment is to establish a simple causal system, but in the human sciences experimental control is difficult or impossible, and inference from data is correspondingly difficult. The obvious explanation of figures concerning human affairs is seldom the correct one, and fallacious reasoning is rife, even when the reasoner is trying to be honest. The following are common types of fallacious reasoning. (*a*) Most air accidents occur in a certain type of aeroplane: therefore that

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type is the most dangerous (it may also be the most commonly used type). (*b*) Over the past few years the infant death rate has been steadily decreasing and the consumption of milk has been increasing: therefore milk keeps babies alive. (In giving this as an example of fallacious reasoning we do not imply that milk is not good for babies and their mothers.) (*c*) In the year after some change in policy, juvenile crime fell by a certain amount as compared with the previous year: therefore the policy change was effective (the fall may have been no greater than changes that occurred year by year before the change in policy). We would not expect all pupils to become expert in spotting all fallacies or in drawing correct conclusions from data, but at least they should develop a habit of examining critically and accepting with reserve conclusions drawn by other people.

11. Some of the more elementary technical devices of statistical method are part of the small change of public controversy and intercourse, and all citizens need to have sufficient understanding of them to appreciate the message they convey and to avoid some of the grosser misunderstandings that accompany their misuse. Not only technical journals but also newspapers and popular magazines and journals abound in charts, and averages and percentages are quoted without apology or explanation. Charts can mislead if unsuitable scales are chosen or the zero is not properly shown. Averages, although useful, often give information so incomplete that they mislead, and account must then be taken of the spread of the numbers averaged. Some averages and ratios are in fact *weighted* averages, and comparisons may be affected by changes in the weights as well as by changes in the quantity measured. The death rate is a typical example, and the need for taking account of the age composition of the populations is not always appreciated. Percentages are not always understood, and only recently appeared the fallacy that if daily output is increased by 2 per cent. the increase for a five-day week is 10 per cent.! It may make quite a difference to any conclusion that may be drawn if a percentage changes because the denominator, rather than the numerator, has changed. Surely there is need for the ordinarily educated citizen to know a little of the properties and meanings of these quantities.

12. Some appreciation of sampling is also needed, since the public is often asked to accept some result obtained from a sample survey. In the general election of February, 1950, some newspapers reported every few days the results of public opinion polls, purporting to disclose changes in the opinions of the electorate; and road accident rates are sometimes quoted monthly for single towns; but both sets of figures are given without reference even to the existence of chance fluctuations, which may be large compared with the changes shown. No one can appraise such data except with some appreciation of the effects on them of the errors to which samples are subject. The citizen should have woven into the texture of his thinking the idea that a good sample can convey some information about the universe sampled, and that it does so with predictable errors.

13. One typically statistical concept that pervades much of modern thought is that of an aggregate of individuals, having "collective" characteristics derived from those of the individuals, but quite different in kind. Thus the "unemployed" are not a static body of a few hundred thousands of men: for instance, at any one time they are men who have been out of work for varying lengths of time, and this aspect of unemployment is best described by a frequency distribution* of that time. When we say that the results of intelligence tests correlate with the school performance of children, we are saying something about the aggregate of children, not that each individual child who does well in the test will do correspondingly well in school. The statistical concept arises in many ways in the social and economic worlds, and also in the natural sciences—biology becomes statistical immediately it becomes quantitative, and modern physical theories of matter are confessedly statistical.

14. Probability is an idea that, in statistical thought, derives from the frequency distribution, and has application, not only in scientific work, but also in daily life. Thus the probability of suffering an accident when undertaking some form of journey is thought of as a ratio of frequencies. Simple exercises can help to give a rational as opposed to a superstitious view of the idea of probability; they can accustom the mind to the thought that, in some fields, the probability of (say) accidents can be affected by human behaviour (only this thought makes sense of safety campaigns); and they can familiarize people with the fact that the probability of two unlikely

* In this case the frequency distribution would be shown by a table or a diagram which gives the number, or "frequency", of men out of work for each of the various lengths of time.

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independent events occurring together is very low, and with the idea behind the saying "The pitcher goes often to the well but is broken at last". These points of view come up repeatedly in the experiences of life.

15. The statistical concepts mentioned in the two previous paragraphs are not commonplace, and special steps will be necessary in the schools if they are to become so. We are individuals, more conscious of our individuality than anything else, and it is natural for us to think of society as made up of individuals and nothing more. Often the nearest we get to conceiving of the aggregate as an entity is by personifying it in some super-individual as the "average man". At school, quantitative thinking is developed mostly through the teaching of mathematics and natural science, and in that teaching the Newtonian deterministic or individualistic approach predominates. The frequency distribution and all the ideas that go with it are strange to most school children; they need not and should not be.

16. So far we have mentioned statistical methods and ideas that should, in our view, form a part of general education. Another branch of the subject with which all citizens should have at least a nodding acquaintance is that of economic and social statistics. From time to time all citizens have to fill in returns for official statistical purposes, and it is as well that they should have some appreciation of the uses made of the information. Figures like the cost-of-living index—at present the temporary retail price index—are much used in public discussion, and movements in this particular index influence the wages of many workers. Statistics of health, life and death, of production, of imports and exports, and of the balance of payments between various areas: these are only examples of subjects that are discussed in even the most popular newspapers. Some familiarity with official social and economic statistical information is a help towards an understanding of public affairs.

III. Statistics in the General Curriculum

17. It may be remarked by some readers that most of the aspects of statistics listed above for inclusion in a general education are not peculiar to statistics. This we freely admit, and provided they are taught and taught adequately, it does not matter what name is given to the studies. Indeed, we do not suggest as an ultimate ideal that the general curriculum should include a new "examination" subject called statistics. We think it better that, in the main, due weight should be given to the statistical aspects in teaching other subjects, with perhaps a few lessons in matters that are not covered in this way, and occasional lessons devoted to reviewing and summarizing the statistics of work already done, so as to prevent it from becoming diffuse and ineffective. In the next three paragraphs are given a few suggestions of the ways in which the aspects of statistics discussed in the previous section might be introduced into the general curriculum.

18. The quantitative approach becomes familiar in any subject as soon as precise quantitative statements are substituted for vague qualitative statements, and numerical evidence is provided. Natural science can scarcely be taught in any other way, and much of geography is quantitative. In history numerical data, such as estimates of population, help to give happenings a correct perspective, and we have heard of boys for whom the progress of representative government in this country was much illuminated by plotting a graph of the proportion of the population forming the electorate at different times. It is important, of course, that numerical data should not be presented as "dry figures" unrelated to the rest of the subject, and we would be sorry if lists of populations replaced lists of dates as emblems of the dry-as-dust school. Figures should be presented in a way to stimulate interest (charts help in this, particularly if made by the children), and their connection with the rest of the subject should be brought out.

19. The only way to acquire a balanced view of figures is for children to produce them by observation, subject them to simple manipulations, and speculate on their significance. This is most easily and naturally done in science (see, for example, paragraph 9), but enthusiastic teachers can find ways of doing it in other connections. For instance, it is difficult to use directly the craze for collecting railway engine numbers, but perhaps the urge behind that craze can be directed towards making a road-traffic survey in order to determine the numbers and classes of vehicles passing one or two selected points at chosen periods in the day. Or, the subjects dealt with in newspapers can be classified (political news, criminal news, general news, sport, feature articles, and so on); a few newspapers can then be dissected and the proportion

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of space devoted to each class can be measured. If each newspaper were treated in this way for a few days, it would be possible to see how far these proportions are characteristic. These, and perhaps most practical exercises in applied statistics, are best done as co-operative class efforts.

20. Training in drawing valid conclusions from statistical data cannot be carried very far through the teaching of other subjects; special provision is necessary. We can imagine a teacher in class collecting examples of fallacious and correct reasoning and suggestion from the correspondence and advertisement columns of the local and daily papers, and occasionally spending some time in discussing the validity of the inferences. The whole exercise can be conducted in a light-hearted spirit, but it would be suitable only for children over fourteen or fifteen years old.

21. Some of the teachers we have consulted agree that progress can be made in schools along the lines suggested in paragraphs 17 to 20; others think that statistics will make headway in the curriculum only if it is treated as a separate subject and given a place in the time-table. This is a matter for teachers to settle. Perhaps the experience will vary with the school and, at least as an interim measure, the establishment of statistics as a separate subject may be desirable in some schools. But we are emphatic that the chief good effect that statistics can have in the general education is in affecting the intellectual approach to other subjects and to life. Whatever the kind of provision made for teaching, this ultimate effect should be kept to the fore as the main aim.

22. We suggest that a general education for citizenship would not cover unnecessary ground if it included an elementary introduction to the following statistical techniques: *

Diagrams (bar charts, "pie" charts, iso-type charts, time charts, graphs, economic maps); recognition of the distinction between trends, seasonal movements and random fluctuations in time charts.

Approximations in practical arithmetic; significant figures.

Percentages, rates, ratios, index numbers, compound units (e.g., man-hours), averages (weighted and unweighted), a measure of dispersion.

Frequency distributions, their formation, graphical representation and interpretation; estimation of frequencies between various limits; calculation of mean and (possibly) standard deviation from grouped data.

Simple correlation charts and the idea of correlation.

Probability and simple probability calculations.

Sampling with examples of bias and random errors.

In developing syllabuses on these lines, it would be desirable to teach children to pay as much attention to the meaning and limitation of the data and of the results as to the arithmetical procedures. We do not, however, wish to belittle the importance of arithmetical facility as a foundation for all statistical work.

23. Children will, of course, be introduced to these studies, and proceed with them, according to their ages and abilities. Most of our future citizens will be educated in the Modern Secondary Schools where they are likely to be taught at the best only a part of the techniques of paragraph 22. We hope that their statistical education will be continued in the proposed County Colleges or in whatever forms of adult education are established as alternatives. We are strongly of the opinion that, in any event, from about the age of 13 all children in all types of school should begin to be aware that there is a statistical way of looking at things.

IV. Statistics in the Sixth Form and in Vocational Training

24. There is an element of the special and of vocational training in the education of older children at almost all schools. Children in Modern Schools may receive some preparation for a commercial career; in Technical Schools they may be introduced to some technical subject, and in Technical Colleges† the training is carried further; in Grammar Schools and Public Schools

* Some notes on the teaching of such a syllabus are contained in a pamphlet by Mr. B. C. Brookes entitled "Notes on the Teaching of Statistics in Schools". It is to be published by Messrs. Heinemann.

† Broadly, by Technical Schools we understand secondary schools in which technical education is provided for children under 15 or 16, and by Technical Colleges places that cater for young adults, whether receiving full or part-time training.

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special subjects are studied often as a preparation for further study at the university. Statistics of a specialized kind is important for many careers and special subjects, and should find an adequate place in the training. We emphasize especially that the teaching of statistics in the sixth form of the Grammar School is a development that is desirable, and that has so far taken place in only a few schools.

25. The mathematical specialist will derive satisfaction in finding that statistical theory applies concepts and methods he has learnt in his general mathematics: there is a close analogy between the moments used in describing frequency distributions (the mean, the standard deviation, and so on), and those arising in mechanics (the centre of gravity, the moment of inertia, and so on); probability theory applies the theory of permutations and combinations; and the co-ordinate geometry of the straight line is necessary for expressing the properties of the regression lines in correlation analysis. Mathematical statistics is relatively new and rapid developments are taking place; the budding mathematician can be inspired by the realization that there are new and exciting possibilities for research.

26. Statistical ideas and methods are essential to quantitative biology in all its branches—much of modern statistical method was first developed to describe biological variation and to deal with the planning of and the drawing of conclusions from biological experiments. Engineering and technology are increasingly using statistical methods and ideas, in routine control and research, as the consequences of uncontrollable variations in raw materials, processing conditions, products, and conditions of service, are being realized and dealt with quantitatively. The professional work of the actuary is founded on statistics and the statistical method. Many modern physical and chemical theories are basically statistical. Sooner or later in his career the scientist is almost certain to find the need to use statistical techniques and it is good that he should adopt the right approach and develop the necessary intellectual equipment from the start of his specialist studies and not wait until, in later years, he finds it necessary to go through the difficult business of reorientating his ideas. Statistical methods and ideas are often found to be difficult, not because they are intrinsically so, but because people find it difficult to pick up a new set of ideas after having become habituated to an old set. A comparatively leisurely introduction to statistics at school makes it more likely that the more intensive courses at the university will be assimilated.

27. Pupils who are going to be social scientists, business men, administrators or politicians will require the ability to read and perhaps to construct statistical tables and diagrams, to find their way around official, economic and social statistical data, and to draw sound conclusions as to causes and effects in their complex fields of study. Often these pupils are not very mathematically minded, and therefore need all the more the advantage of a relatively unhurried school course in statistics.

28. Syllabuses will probably be developed for special fields of application, particularly in places such as Technical Colleges which prepare candidates for National Certificates and comparable professional examinations. Generally it should be realized that not many of the students will become practising statisticians, and the general aim should be to teach students to recognize a statistical problem in the given field of application, to know what kind of problem should be referred to a statistician and what kind of solution is possible, and to understand, appreciate critically, and use, the solution. This will involve some practice in the "drill" of making statistical calculations, but the drill should be regarded as the means to the end of understanding and learning, and will probably be forgotten soon after leaving school. Even when taught as an adjunct to some other specialist study, the general educational value of statistics should not be overlooked.

29. The statistical approach should have a proper place in the teaching of the special subject, but it will also be necessary to pay more attention to statistical techniques than is appropriate in general education. At this stage there is room for lessons in statistics as an "option", and this is in line with developments that are already taking place. In the sixth form of some Grammar Schools statistics is explicitly taught as a branch of mathematics, and in Commercial and Technical Colleges there are courses in the subject for commerce and engineering.

V. Teachers and Textbooks

30. The key to the teaching of statistics in schools is the provision of suitably equipped teachers. The teaching of statistics in universities is developing, and teachers with a full appre-

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ciation of the statistical aspects of their subjects are being trained. With a continuation of this development the things we advocate in this memorandum will slowly come to pass. In the meantime there is a large body of teachers who know little or nothing of statistics, and these need to be given a knowledge and appreciation of the subject. There seems to be a need for vacation or evening courses for teachers, and it may be that these should be given largely by experienced school teachers and by lecturers in close touch with school teaching. A course on statistics by a mere statistical expert, particularly if he has more mathematical statistics than imagination, is likely to do more harm than good.

31. There are available several textbooks in which teachers can find instruction for themselves. No one book is likely to be completely satisfying, but this is inevitable, for the different approaches and points of emphasis of different authors all make their contribution to understanding. No special provision for teachers is called for. There is, however, need for books for use in the classroom—books in which suitable exposition is coupled with a wealth of exercises and examples—and for some inexpensive statistical tables. At present, teachers of statistics in schools can only glean their material for class use from parts of other textbooks and from original sources, and the time and labour involved in this must be an impediment to the spread of statistical studies in schools. Chapters on statistics and related subjects that appear in some textbooks on arithmetic and algebra are a help, but they are not enough. Here again, in the writing of statistical textbooks for schools, is a field of activity primarily for those experienced in teaching. We understand that one or more books are in preparation, and look forward to seeing this gap in statistical literature adequately filled before very long.

VI. Statistics in School Examinations

32. The content of the work in secondary schools, at least in the upper forms, is largely determined by the syllabuses organized by the General Certificate Examination authorities in collaboration with the schools. These syllabuses and examinations, especially in mathematics, can therefore have an important effect on the development of the teaching of statistics in schools. The inclusion of some questions with a statistical bias in subjects that use statistics, such as biology and economics, will encourage attention to the statistical aspects of these subjects in teaching.

33. We think that some statistics should appear formally in the syllabuses for mathematics. As yet there is little experience of teaching statistics in schools, and therefore, in our opinion, syllabuses should be framed to allow its introduction to take place gradually. It would be better for the subject to be introduced to a modest extent at all levels rather than to a specialized degree in separate papers. Many teachers of mathematics without experience of the teaching of statistics would probably hesitate to prepare pupils for specialist papers in statistics, but would be quite ready to prepare their pupils for the opportunity of answering some statistics questions as alternatives in mixed papers. There is another reason why we do not at present recommend the teaching of statistics in schools as an advanced specialist subject. It is unlikely that such specialist knowledge will be accepted by the university as exempting the new entrant from any part of his degree course, so that the schoolboy specialist will be disappointed on arriving at the university to find that he must start again with a class of beginners. The universities would prefer a pupil with a sound knowledge of the elementary ideas to one who has already covered, and possibly not in quite the way required, some of the more advanced aspects of the subject. A similar view would probably be held by professional bodies such as the Institute of Actuaries.

34. In general, school subjects can be taken at three levels—Ordinary, Advanced and Scholarship. At the Ordinary level there are, in some subjects, two or three alternative syllabuses. In mathematics, for instance, some examining authorities include statistics in one of the alternatives. Papers, with alternative sections or questions on statistics, could provide for, *inter alia*, pupils who are primarily interested in biology, economics, geography or in social studies; and similar arrangements at the Advanced and Scholarship levels provide for pupils studying the exact sciences or mathematics as their principal subjects. In the Appendix we give the statistical content of the syllabuses of several authorities, adding a few comparative comments at the end on the examination at Ordinary level. There is variety in the provisions made for statistics and in the scope of the syllabuses, and it seems good that this should be so while the teaching of the subject in schools is in an experimental stage. Experience with these syllabuses, and with others that

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may be instituted in the future by authorities not now providing for statistics, will show the best directions for development.

APPENDIX

I. Statistics in the General Certificate of Education Examination

Information regarding the place of statistics in their syllabuses for the General Certificate of Education 1951 was sought from the eight examining authorities. The information obtained is summarized below.

1. *University of Bristol*
2. *University of Durham School Examinations Office*
3. *Oxford and Cambridge Schools Examination Board*
4. *Welsh Joint Education Committee*

Statistics is not included in the G.C.E. syllabuses.

5. *University of Cambridge Local Examinations Syndicate*

(*a*) Statistics is included at Ordinary Level* in one of the three Alternative Mathematics Syllabuses (Alternative C). The paper (3 hours) will consist of—

Section A:	Pure Mathematics	6 questions.
Section B:	Mechanics	4 questions.
	Statistics	4 questions.
	Additional Items of Pure Mathematics .	4 questions.

Candidates must not answer more than four questions from Section B.

The *syllabus* of Section A (Pure Mathematics) and Section B (Additional Items of Pure Mathematics) is as follows:

Functions of a variable and their graphical representation.

Determination of a function from a straight line graph.

Meaning of dy/dx and its determination in simple cases.

The form of the functions $mx + c$, kx^n ($n = 3, 2, \frac{1}{2}, -1, -2$), $\sin x$, $\cos x$, e^x, e^{-x}, $\log x$, their graphs and derivatives. (Proofs will not be required.)

Circular measure. Trigonometrical ratios of angles of any magnitude. Use of sine, cosine, tangent, and logarithm (including the use of four-figure tables).

The solution of triangles and determination of area (only the sine and cosine formulae and the formulae $\frac{1}{2}\,bc \sin A$ and $\sqrt{s(s-a)(s-b)(s-c)}$ will be needed. (Proofs will not be required). Simple trigonometrical problems in three dimensions.

Differentiation of a sum, product, quotient and a function of a function (simple examples only). Applications to small increments, rates of change, maxima and minima (questions will be soluble without the use of the second derivative).

The definite integral and its representation as an area; integration as the inverse of differentiation. Integration of simple functions (excluding integration by parts and by change of variable other than $x = kt + l$); application to plane areas and volumes of solids of revolution.

Simple problems on arrangements and on choice and chance.

The binomial theorem for a positive integral index and its use for simple approximations. (Questions on the greatest term and on sums and properties of the coefficients will not be asked.)

The *syllabus* of Section B (Mechanics) is as follows:

Kinematics of a particle moving in a straight line; its graphical treatment; motion with uniform acceleration. Composition and resolution of velocities and accelerations.

Composition and resolution of forces; moments. (An experimental basis is sufficient; proofs of the fundamental theorems of statics will not be required.)

Equilibrium of a particle and of a rigid body under coplanar forces.

Friction.

* As an example of the amount of mathematics required in one Ordinary Level Mathematics Alternative we have here shown, not only the statistics syllabus, but also the mathematics syllabus included in the same Alternative.

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Simple examples of the motion of a projectile.

Newton's law of motion and the ideas of force, momentum, energy, work, power. (The use of absolute units will not be required.) The conservation of momentum and of energy in straight line motion.

The *syllabus* of Section B (Statistics):

The tabulation and graphical representation of statistical data illustrated, e.g., by population, trade, growth of plants, examination marks. Averages; mean, mode, median. Moving averages. Index numbers. Measures of dispersion; quartiles, mean deviation, standard deviation. Frequency distributions. The binomial distribution. General ideas of sampling; standard error. Applications of the formulae $\sqrt{(pq/n)}$ and $\sigma/\sqrt{n}$ for testing the significance of a proportion and a mean in large samples.

(*b*) Statistics is included at ADVANCED LEVEL in Mathematics, Paper II. This paper (3 hours) consists of—

Section A:	Geometry	2 questions.
	Mechanics	5 questions.
Section B:	More advanced topics in Pure Mathematics and Mechanics . . .	4 questions.
	Statistics	4 questions.

Candidates must not answer more than four questions from Section B. Full marks will be obtainable for about 10 questions.

The *syllabus* of Section B (Statistics) is as follows:

As for Ordinary Level paper above, with the addition of:

Proofs of the formulae $\sqrt{(pq/n)}$ and $\sigma/\sqrt{n}$ for the standard error of a proportion and a mean.

Elementary ideas of association. Scatter diagrams, leading to the ideas of linear regression and correlation. The calculation of correlation coefficients and the equation of regression lines.

(*c*) Statistics is included at ADVANCED LEVEL in Further Mathematics Paper II.* This paper (3 hours) consists of—

Section A:	Calculus	5 questions.
Section B:	Differential Equations and Mechanics .	6 questions.
	Statistics	5 questions.

Candidates must not answer more than 5 questions from Section B.

The *syllabus* of Section B (Statistics) is as follows:

The addition and multiplication laws of probability, with simple illustrations.

The normal distribution. The Poisson distribution; its derivation from the binomial distribution.

Standard error of a difference of means.

Elementary treatment of significance of a mean and of a difference of means in small samples.

6. *University of London Matriculation and School Examinations Council*

(The following details refer to the General Certificate of Education as from 1952):

(*a*) At ORDINARY LEVEL, Pure Mathematics Alternative Syllabus A will consist of the following seven papers, of which candidates will have to take three:

* In 1952 Statistics will not be included in the Further Mathematics Papers, but the Syndicate will be prepared on application from a school to provide questions on Statistics (on the 1951 syllabus) as an alternative to questions on some other equivalent part of the syllabus.

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(i) Arithmetic and Trigonometry.
(ii) Algebra.
(iii) Geometry.
(iv) Further Algebra, Geometry and Trigonometry.
(v) Co-ordinate Geometry and Calculus.
(vi) Statistics.
(vii) History of Mathematics.

The work in each of the last four papers will be such that it may be done in two periods a week for one year. Each of these papers will be of $2\frac{1}{2}$ hours' duration.

The *syllabus* of paper (vi) Statistics will be as follows:

The syllabus, in which the order of the topics is not necessarily a suitable teaching order, aims at a treatment of statistics which shall be broad rather than deep, indicating the fundamental elementary concepts and including some simple calculations. It is assumed that illustrative material will be drawn from such fields as economics, biology and psychology, and that some statistical data will be collected by the candidates themselves.

The scope of statistics.

The collection and interpretation (numerical and descriptive) of data.

Design of questionnaires and of samples; bias.

Tabulation. Pictorial representation, bar charts. Graphs of statistical data, time-series, use of moving averages for removing seasonal fluctuations, secular trend, parallel movement.

Frequency distributions, histograms, cumulative frequency diagrams.

Measures of central tendency: the arithmetic mean (calculated from a set of numbers and from a frequency distribution). Weighted means in economic and vital statistics (e.g., index numbers, standardized death rates).

The median (determined graphically) and the mode.

Measures of dispersion: quartiles, percentiles (determined graphically).

Calculation of the standard deviation from a set of numbers and from a frequency distribution.

Meaning of correlation and of regression. Scatter diagrams. Graphical treatment of regression.

Correlation by ranks with calculation of the coefficient of rank correlation by using a small number of items.

Elementary ideas on interpretation and reliability of correlation coefficient.

(*b*) At ADVANCED LEVEL, the examination in Applied Mathematics will consist of two papers (3 hours each), and will include some elementary statistics questions. Candidates are informed that the questions on statistics need not be attempted in order to obtain full marks.

The *syllabus* for Applied Mathematics includes:

Elementary ideas of statistics, frequency diagram, calculation of the mean, standard deviation, standard deviation of the mean.

7. *Universities of Manchester, Liverpool, Leeds, Sheffield and Birmingham Joint Matriculation Board*

At ADVANCED LEVEL*, the subject "Mathematics" consists of two papers. All candidates must offer Paper I. In Paper II candidates must offer either Alternative A, or Alternative B, or Alternative C. Statistics is included in—and, in fact, is the major part of—Alternative B. The paper (3 hours) will contain eight questions, of which candidates must answer not more than six.

* At ORDINARY LEVEL a new Alternative syllabus will be introduced in 1953 in which one of the six papers (from which candidates will have to choose two) is on statistics.

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The *syllabus* of Paper II, Alternative B is as follows:

(i) The first order differential equation (*a*) with variables separable, (*b*) linear, with applications to, *inter alia*, rectilinear motion, the exponential law of growth or decay and the rate of chemical reactions. (Knowledge of chemical and physical laws will not be assumed but the ability to express stated laws mathematically may be tested.)

(ii) Probability. Application of the addition and multiplication laws to the calculation of probabilities in simple problems. Frequency distributions. Mean, variance, standard deviation. The histogram. Probability distributions. The binomial distribution, its mean and variance. Graphical and numerical treatment of the normal distribution and its relation to the binomial distribution, with the use of small tables.

(iii) Populations and samples. Mean and variance of a sample. Estimates of the mean and standard deviation of populations from those of a large sample. Calculation and precise meaning of the standard error of the mean of a random sample, using the formula $\sigma/\sqrt{n}$. Scatter diagrams. The meaning and graphical fitting of regression lines. The calculation of correlation coefficients.

8. *Oxford Local Examinations*

The subject Pure Mathematics and Statistics is being provided as an alternative at ORDINARY LEVEL. Two papers (2½ hours each) will be set. The questions will be such as to test understanding of statistical problems, and ability to interpret results and to avoid common pitfalls. Candidates will be expected to show a thoughtful approach to the subject, rather than merely to quote definitions and to apply formulae blindly. The amount of calculation required will not be great, but arithmetical accuracy and the intelligent checking of calculations will be considered in the marking, as also will competence and neatness in the tabular and graphical presentation of results.

The *syllabus* is as follows:

Pure Mathematics

Functions of one variable and their graphical representation. Questions will be limited to simple algebraic functions, including cubics and $1/(a + bx)$, $\sin x$, $\cos x$, e^x, e^{-x}, $\log x$, and simple combinations of these (e.g., xe^{-x}, e^{-x^2}).

Differentiation of these functions, rates of change, maxima and minima. Integration of functions possessing indefinite integrals, including simple uses of integration by parts. Definite integrals, areas, first and second moments.

Permutations and combinations. Binomial theorem for positive integral index.

Use of simple mathematical tables of standard type, including proportional parts and linear interpolation.

Principles and use of simple slide rule.

Probability

Elementary probability theory. Addition and multiplication of probabilities and simple problems of "urn" type. Concept of expectation.

Frequency Distributions

Tabulation and graphical representation of data.

Discrete and continuous variation. Histograms, frequency polygons, and cumulative frequency diagrams. Elementary descriptive properties of distribution in respect of skewness, limitation of range, etc.

Mean (arithmetic), mode, median. Standard deviation, variance and range. Calculation of mean and standard deviation using arbitrary origin, with or without grouping (NOT Sheppard's correction). Standard measure (i.e., expression of measurements relative to arithmetic mean and in units of standard deviation).

Particular distributions: Binomial, Rectangular, Normal—including equation, main characteristics, and elementary uses of tables of normal integral, but no proofs. (Not Poisson distribution.)

Two-variate Distributions

Tabulation. Scatter diagrams. Descriptive and graphical treatment of linear regression. Drawing of regression lines by eye, and expression by equations. Defini-

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tion and interpretation of product-moment correlation coefficient. Simple contingency tables, and expected frequencies calculated on hypotheses of independence. Discussion of results without tests of significance.

Sampling

Distinction between population parameters and sample statistics. Repeated sampling from normal distribution. Distribution of means of these samples. Standard error of these means ($\sigma/\sqrt{n}$). Tests of significance of difference between mean of single sample and postulated population mean, and fiducial or confidence limits to mean derived from sample. (No rigorous treatment expected, but questions on general principle and application to normal distribution may be set.)

Index Numbers

Introduction to their purpose, calculation, and use in economic problems.

Time Series

Graphical representation and time series. Pitfalls.

II. Summary and Comment on Appendix

At this stage we wish to comment tentatively only on the extent to which the syllabuses at the Ordinary Level are likely to cater for the pupils whose prime interests are not mathematical. Such provision is, or will be, made by the Cambridge, the Oxford Local, the London authorities and the Joint Matriculation Board of the Northern Universities. The requirement of the non-mathematical specialist seems to be most nearly met by the Cambridge option, involving a single three-hour paper containing questions in (A) Pure Mathematics and (B) Mechanics and Statistics. For London, the syllabus in statistics, though set out in greater detail than for Cambridge, does not appear to call for a greater depth of knowledge—except for the requirement of an understanding of correlation; but coupled with this 2½-hour paper purely on statistics the candidate must take two additional papers in mathematics. This might call for a fuller mathematical course than a boy who was specializing in biology or the social sciences could absorb. The Oxford Examination at the Ordinary Level contains two 2½-hour papers devoted to the subject of Pure Mathematics and Statistics, the Mathematics being ancillary to the Statistics. The syllabus for Statistics appears to be more ambitious than that proposed by either Cambridge or London, and to call for a teaching programme which few boys, interested primarily in economics or biology, could be expected to absorb at this stage.*

* It has now been decided by the Oxford Local Examinations authorities that the syllabus in Pure Mathematics and Statistics is too difficult for Ordinary Level standard and, in and after 1953, this syllabus will be regarded as an alternative to Pure and Applied Mathematics at Advanced Level.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS.

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1.—*Introduction to Statistical Analysis.* By Wilfred J. Dixon and Frank J. Massey, Jr. New York and London: McGraw Hill, 1951. x + 370 pp. 9″. 38*s.* 6*d.*

"This textbook has been written for a basic statistics course to be taken by students from all fields in which statistics finds application". "The only mathematical ability assumed of the student is a knowledge of algebraic addition, subtraction and multiplication". "The order and emphasis of topics are based largely on the recommendations for a basic course in statistics stated by the committee on teaching of statistics of the National Research Council".

The first 200 pages consist of familiar material. After some discussion of fundamental concepts and methods, there follows an account of regression, correlation, analysis of variance and covariance, the binomial and Poisson distributions, and uses of χ^2. Modern researches of the last ten to fifteen years exercise a large influence on the remainder of the book proper. This section discusses power functions, estimation from order statistics, non-parametric tests, sequential tests, and the analysis of sensitivity data. An appendix of 72 pages consists of 26 statistical tables, a collection which must be one of the most extensive available in an elementary text.

Credit is due to the authors for including class exercises with each chapter, so that students can observe the agreement between stated mathematical theory and the results of experimental sampling. In such a clear and detailed account there should perhaps have been some illustration of the use of linear transformations to facilitate the calculation of means, variances and covariances. Although a paragraph on p. 166 mentions the principal results, the student will presumably imitate the laborious numerical example on p. 167. Another computational omission concerns the use of graphical methods to operate the sequential test for differences between proportions; the relevant arithmetic is more neatly overcome by Barnard's handicap-penalty scoring process.

Many of the topics in the last section of this book, although of interest in themselves and of "wide applicability", are not, I believe, so widely applied as subjects like the sampling of finite populations without replacement or the analysis of time series, neither of which are included. Modern developments should not displace more basic material, and while the book gives a helpful introduction to these recent advances, its construction raises the question, in a rapidly expanding subject, of what to insert and what to omit: I hope that the solution will not lie in the direction of teaching the student less and less about more and more.

R. L. PLACKETT.

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2.—*Introduction to Statistical Method.* By B. C. Brookes and W. F. L. Dick. London: Heinemann, 1951. viii + 288 pp. 21*s*.

This book, as the authors make clear in the Preface, is primarily intended for use in schools, and deserves particular attention as a pioneer in this field. A more suitable pair of authors could scarcely be found: one is an ex-schoolteacher, well known for his advocacy of the teaching of statistics in schools, and the other has had considerable experience of the application of statistics in industry. The scope of the book, which for the most part is quite orthodox, is indicated by the chapter headings: Part I has chapters on The Representation of Numerical Data, Measures of Position, Measures of Dispersion, Probability, The Binomial and Poisson Distributions, and The Normal Distribution; Part II deals with Tests of Significance, Regression, Correlation, Goodness of Fit and Contingency Tables, and Planning Statistical Experiments. The authors say in the Preface, "The scope of the book has not been determined by any examination syllabus. It provides more than is necessary at present to cover the optional statistics syllabuses of the General Certificate examining bodies, and it covers the methodological part of the Certificate Examination of the Royal Statistical Society. It has not been written for students specializing in mathematics; the reader who is capable of attaining the Ordinary Standard in Mathematics in the General Certificate should have no mathematical difficulties". All mathematics except the simplest algebra is relegated to "mathematical notes" which may be omitted.

The book is particularly rich in examples, especially in the first part. Many of these concern such everyday subjects as motor-car registration numbers and cricket scores, and the students are encouraged to do their own practical work: "Each member of the class should be allotted a task of day-to-day recording. The data collected by this means should be summarized from time to time and filed for further analysis later in the course."

In detail the book is rather uneven. The exposition is often excellent—the chapter on χ^2, for example, could hardly be better; and yet the discussion on p. 187 of the fitting of regression lines and the principle of least squares seems unduly confusing. There are some delightful illustrations, such as Fig. 47, illustrating the two regression lines, but Figs. 13, 14, 22 and 23, which consist of overlapping histograms, may be quite misleading.

There are a number of minor misprints and other small errors which will soon be spotted. In particular the two lines in Fig. 51 are drawn with the wrong slopes. More serious are a number of conceptual errors which may confuse not only alert pupils but also teachers, many of whom will have had no practical experience of statistical methods. It may be useful to indicate some of these here: (*a*) The "proof" that ${}^nC_0 = 1$ is unsound. (*b*) The solution of the example at the foot of p. 148 assumes that equal numbers of students are placed in the four classes, which would not necessarily be true. (*c*) The discrepancy between m_n and m on p. 157 is due to grouping rather than sampling errors. (*d*) In the example on p. 161 it is true that numerically equal errors are of different importance, but the scales of m and v are quite different, and the essential point is that equal coefficients of variation are equally important. (*e*) In the last chapter a simplified version of the analysis of variance is presented, based on the range between treatment means. The 1 per cent. points of the distribution of the ratio of range to true standard deviation are tabulated and used, although in the examples the error standard deviation is often based on as few as 6 degrees of freedom.

It is disappointing that the high standard reached in many parts of this book is not maintained, but one hopes that the authors will have an early opportunity to revise the book in a second edition. Part I may be obtained separately. P. ARMITAGE.

3.—*Statistics for Economics and Business.* By D. W. Paden and E. F. Lindquist. New York and London: McGraw-Hill, 1951. ix + 276 pp. 9″. 32*s*.

This is a beautifully bound and clearly printed elementary text-book on statistical methods. Associated with it is a separate "Manual" of exercises (17*s*.) arranged for the answers to the questions to be written in appropriate spaces, reminding one of intelligence test papers—even grids for graphs are provided. The idea is good.

The general approach is logical, with a possible exception in the treatment of index numbers before simple averages. After an introduction the authors deal with elementary concepts, including percentages and weighting, a subject that can suitably be followed by index numbers when these are treated as weighted averages of price or quantity relatives. Following a discussion of frequency distributions and the representation of them by diagrams, there are separate chapters on measures of central tendency and variability. These lead to the normal curve of distribution (with two tables), and hence to sampling and the unbiased errors that are involved therein. The discussion on testing hypotheses, the significance of differences and confidence intervals is more extensive than is usually given in an elementary text-book. Here there is a natural break in

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the development of the ideas, with a treatment of time series, seasonal variation and trends leading to correlation, which again picks up the ideas of errors and mentions the analysis of variance.

The price examples for index numbers and employment examples for seasonal variation are figures from the U.S. Bureau of Labour Statistics but most of the examples are artificial ones.

Two examples of the treatment of statistics will be given, one from the end and the other from the beginning of the book. The correlation coefficient is defined fundamentally as being the average value of the product $\frac{x}{\sigma_x} \cdot \frac{y}{\sigma_y}$, i.e., $\frac{1}{n} \Sigma \left(\frac{x}{\sigma_x} \cdot \frac{y}{\sigma_y} \right)$, when x and y are measured from their respective means, but the derivation therefrom of the usual formula

$$r = \frac{\Sigma XY - n\bar{X}\bar{Y}}{n\sigma_x\sigma_y} \qquad X = x + \bar{X}$$

is simply stated as a fact to be accepted. Further the only direct calculation of r in the text (i.e. excluding the appendices) is in terms of the fundamental definition where 7 pairs of values show perfect correlation ($r = 1$).

In some respects the treatment of errors arising from rounding is pleasing. Apparently in a total of $71 \cdot 05 \pm 1 \cdot 56$ the authors would say there are two significant figures, for if 71 is not correct to the nearest integer, both figures are significant in the sense that the correct answer could not be either 66 or 74, either of which could be consistent with there being only one significant figure, the 7. On the other hand, to show a sum which is clearly $35 \cdot 863 \pm 0 \cdot 055$ as $35 \cdot 7$ (even when this is modified by a footnote) is not making full use of the information provided.

A striking feature of the book and manual is the way examples have been chosen to reduce the amount of computation to negligible proportions. This simplification has the advantage that it illustrates statistical concepts clearly. Should it not, however, be supplemented by examples that show more clearly the practical advantages of short-cut methods, and which prevent students from thinking artificial and easy examples are typical or that the results can have real meaning? The primary concentration on obtaining a reasoned understanding of statistical method has resulted in the normal method of calculating a standard deviation by working from an assumed origin being relegated to an appendix whilst a similarly relegated calculation of a correlation coefficient from a two-way table is illustrated by a 3×2 table with a total frequency of 10 items. The last exercise in the manual, for computation after the student has worked through 265 pages of text-book and 131 pages of manual, involves the calculation of a correlation coefficient and regression equation. It starts by telling the student to calculate $\bar{X}$ from a list of 8 values ($\bar{X} = 4$ dollars exactly), and in turn to calculate $\bar{Y}$ ($= 5$) σ_X ($= 1\frac{1}{2}$) and σ_Y ($= 2\frac{1}{2}$). After this, without further specific guidance, the student is requested to make the relatively substantial intellectual jump required to calculate r.

One wonders if it is necessary to take students along such a slow path, and to recommend them not to attempt to master, for example, the usual methods for calculating standard deviation and correlation coefficients in a first course, a course designed for undergraduates meeting three or more hours a week. After a course of similar length we in Britain would expect students to make such calculations in the practical way. The authors, however, have apparently given these considerations careful thought, and in the light of experience think their approach is appropriate.

H. S. BOOKER.

4.—*Values and Integrals of the Orthogonal Polynomials up to* n = 26. By D. B. DeLury. University of Toronto Press, 1950 (London: Oxford University Press). 33 pp. 10″. 3*s.* 6*d.*

It is well known that the graduation of n equidistantly spaced observations y_j by a polynomial is greatly facilitated if the so-called "orthogonal polynomials" $\xi'_i(x)$ are used. Existing tables of these polynomials cover the following ranges:

Reference	*Number of Observations*	*Degree of Polynomials*
Fisher & Yates (1948) . . .	$n = 3$ (1) 52	$i = 1$ (1) 5*
Anderson & Houseman (1942) .	$n = 3$ (1) 104	$i = 1$ (1) 5*
Van der Reyden (1943) . . .	$n = 3$ (1) 52	$i = 1$ (1) 9*

The present table is confined to numbers of observations $n = 3$ (1) 26, but extends the degrees of the tabulated orthogonal polynomials to their complete range $i = 1$ (1) $n - 1$. Provision is therefore made for a high degree graduation of the n observed y_j, and, in the limiting case, the fitted polynomial of degree $n - 1$ passes through the n points exactly, agrees with the Lagrangian

* For small n the range of i is curtailed.

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interpolation polynomial, and leaves no degrees of freedom for the estimation of the residual error. The question may therefore rightly be asked as to what would be the purpose of such high-degree graduation.

A second, if not the main feature of this publication is the tabulation of the definite integrals of the orthogonal polynomials.

In the Preface to the tables we read: "The principal purpose of compiling these tables is to supply the arithmetical basis for a numerical integration procedure, appropriate to situations in which the observed or measured ordinates are subject to a random error". In fact the tables deal more particularly with the following situation:

Given that the observed $y_j = \eta_i(j) + z_j$, $j = 0, 1, \ldots, n-1$ where $\eta_i(x)$ is a mathematical function "adequately described" by a polynomial of degree $\leqslant n-1$ and the z_j are normal independent residuals, find an estimate of (a) $\int_0^{n-1} \eta_i(x)dx$ and (b) $\int_{-\frac{1}{2}}^{n-\frac{1}{2}} \eta_i(x)dx$.

The procedure advocated for this estimation consists of two steps:

(i) Determine an estimate of $\eta_i(x)$ in the form of the familiar fitted polynomial

$$Y(x) = b_0 + b_1 \xi'_1(x) + \ldots + b_r \xi'_r(x).$$

(ii) Find

$$\int Y(x)\, dx.$$

Whilst for (i) the customary procedures and tests of significance are used, (ii) is facilitated by the tabulation of the integrals

$$I_i(n) = \int_0^{n-1} \xi_i(x)\, dx; \quad J_i(n) = \int_{-\frac{1}{2}}^{n-\frac{1}{2}} \xi'_i(x)\, dx$$

at the foot of each table of the $\xi_i(x)$ below the customary tabulation of the sums of squares $\Sigma\, \xi'^2_i$.

The Introduction gives examples of the estimation of integrals, including one for the approximate evaluation of a double integral.

The Special Committee on Applied Mathematical Statistics of the National Research Council of Canada as well as the Ontario Research Foundation have sponsored this project.

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H. O. HARTLEY.

5.—*Drei Perlen der Zahlentheorie*. By A. J. Chintschin. Berlin: Akademie-Verlag, 1951. 61 pp. $8\frac{1}{4}''$.

This little booklet contains the exposition and solution of three problems of additive number-theory. During the war Khintchine (to give his name the spelling more familiar to English readers) replied to a request from a Russian soldier for mathematical material and later published his letter in print. The present book is the German translation of the second Russian edition.

Additive number theory is of some importance to mathematical statisticians, since sequential tests can be described in terms of the addition of integers and distribution of their sums. The problems dealt with in the book under review do not lead to any immediate applications, but they exhibit the peculiar attraction of number theory, to which the greatest mathematicians of all times have paid tribute. They are also typical in that they concern questions easily stated and understood, but which have long eluded all attempts at a solution.

The first question is this: Let the set of all positive integers be arbitrarily divided into a finite number of subsets. Does there always exist at least one subset such that it contains an arithmetical progression of given length? The affirmative answer was first given by van der Waerden in 1928, but the proof given in this book is due to Lukomskaya.

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The second question deals with the "density" of a series of increasing positive integers. This is defined as the lower limit of $A(n)/n$, where $A(n)$ is the number of terms not exceeding n. Landau and Schnirelmann noticed that in all known examples the density of the (ordered) logical sum of two series was always at least equal to the sum of the densities of the constituent series. They conjectured in 1931 that this was a general rule, but it was only in 1942 that H. B. Mann (the well-known statistician) succeeded in proving the theorem. The author gives a simplified proof, due to Artin and Scherk.

The third question asks whether every positive integer can be expressed as the sum of a fixed number of nth powers. It has long been known that every natural number is the sum of four squares or of nine cubes. Waring conjectured that a similar statement holds for every n. The proof was first given by Hilbert in 1907, and later by Hardy and Littlewood and by Winogradow. In this book an "elementary" proof is given, due to Linnink, which uses the concept of density.

All three proofs are elementary, in the sense that they use only simple ideas. However, they are very far from easy. This brings us to a problem which is of importance to us in view of the appearance of books on statistical theory which claim to use only the simplest tools, but are nevertheless extremely difficult to read with understanding. What, then, makes a mathematical argument difficult? The reviewer thinks that the following is required of a reader: he must remember the relevant definitions and earlier stages of a proof, he must be able to concentrate on every step and see its essential contents, and he must in retrospect understand the necessity for every step and its logical economy. These are often requirements difficult to satisfy, and the author himself can help or obstruct. Khintchine makes the reader's burden as easy as can be expected, though he cannot substitute the initiative which the reader must provide for tackling the task. The first proof, in particular, which occupies merely five pages, can be recommended to anyone who wishes to test his own ability to mathematical concentration. S. VAJDA.

6.—*Statistische Methoden für Naturwissenschafter, Mediziner und Ingenieure.* Von Arthur Linder. 2nd edition. Basel, 1951. 238 pp. $9\frac{1}{2}'' \times 6\frac{1}{2}''$. Price: bound 30 fr. (Sw.), stitched 26 fr.

The first edition of this book was reviewed in this Journal in 1946. In the new edition, apart from minor alterations, the following topics have been added: Discriminatory Analysis, Generalized Distance, Analysis of Variance. The latter is contained in a new section, but the remarks on deviations from regression lines in an earlier chapter (p. 109) are not organically connected with it.

The design of the book has remained unchanged. After an introductory section there is Section 1, on various parameters, and Section 2, on how to carry out tests of significance. The new Section 3, on Analysis of Variance, is followed by Section 4, "Theory of Samples", which contains the proofs for the procedures of Section 2. The presentation is based on R. A. Fisher's work, but the theory of estimation is not mentioned, except for verbal descriptions of the concepts of "consistency", "efficiency" and "sufficiency" in the Introduction. Neyman-Pearson theory is entirely absent.

There may be some justification for the separation of rules from reasons, but such a plan has obvious dangers. The reader will not always know what specific test he ought to use, or whether any test that appeals to him is legitimate, unless he thoroughly understands the theory. But the author has not always made it clear where normal theory is exact, and where it is only a convenient approximation. He does not give sufficient criteria for knowing the difference between a "large" and a "small" sample, and such remarks as "provided the coefficient of correlation of the parent population is not near to unity" (p. 104) are not very helpful. Fisher's $z = \frac{1}{2} \log [(1 + r)/(1 - r)]$ is stated to be normally distributed, but this is, of course, only approximately true. Degrees of freedom are rather dogmatically introduced, which could not be otherwise, if the relevant theory is relegated to a later chapter. Fiducial limits are mentioned (p. 120), but the reasons for the introduction of such a concept are not stated.

It will be seen that the reviewer is critical of the whole plan of the book. But he is glad to mention that Section 4 by itself is a pleasant presentation of normal theory (for those who like n-dimensional geometry). The book is written in German, for "scientists, physicians and engineers" trained in Continental schools, and it should perhaps not be judged by standards appropriate to text-books for British and American readers.

Print and paper are excellent, and no austerity measures prevent a Swiss publisher from printing the same figure twice or even three times on different pages. Very few misprints have been found (on p. 154, equations (2), (3) and (5) should have s^2 for s in the index) and the tables are clearly printed. Table V allegedly shows critical values of r^2, but the reviewer was unable to understand, from the six lines of explanation on p. 105, what its various columns mean. S. VAJDA.

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7.—*Det Statistiske Departement*, 1920–50. Copenhagen, 1951. 153 + vi pp. 9″. 3 Kr. (Statistiske Meddelser, IV, 139, 4.)

Fortegnelse over Norges Offisielle Statistikk, 1828–1950. 97 pp. (Norges Offisielle Statistikk, xl, 63.)

Statistisk Sentralbyrå Gjennom 75 *År. Tre* 25-*Årsmeldinger*. 53 pp. (Norges Offisielle Statistikk, xl, 65.)

These journals are published by the Danish and Norwegian official statistical offices respectively. The numbers under review are devoted to historical surveys of the activities of these offices.

The Danish publication gives a brief description of the Statistical Department's organization with some reference to its contacts and co-operation with the statistical offices of foreign governments and international agencies. This introduction is followed by a detailed account of work carried out between 1920 and 1950 in each of a number of fields of economic and social statistics including population, social conditions, production, external trade, transport, finance, national income, consumption and prices. The booklet has been designed as a guide for the ever-increasing number of persons who use the Department's statistical publications and information services. To aid foreign readers, the preface and the table of contents are also give in French.

Both the Norwegian publications were issued to mark the seventy-fifth anniversary of the founding the Central Bureau of Statistics as an independent department. The first one is published in bilingual form, the alternate language again being French. It contains an inventory of Norwegian official statistics covering the years 1828 to 1950 and replaces previous inventories which together covered the earlier years of the period. For the most part it consists of a chronological catalogue of the publications in each of the several "Series" of Norwegian official statistics, but there is also a list of other statistical works published by the Central Bureau, as well as a brief subject classification and an index.

The second Norwegian publication gives a report of the activities of the Central Bureau of Statistics during the years 1926 to 1951 prefaced by the two reports for the twenty-five year periods 1876 to 1901 and 1901 to 1926 respectively, these latter being reproduced in their original form. The publication therefore contains a complete record of the career of the Bureau since its foundation as well as an outline of the development of Norwegian statistics over the last seventy-five years.

T. M. RIDLEY.

8. *De Juiste Maat*. By J. Sittig and H. Freudenthal. Leyden: L. Stafleu, 1951. 402 pp. 9½″. 20*F*.

The "Right Size" describes a survey carried out during August, 1947, into the body measurements of 5,001 Dutch women. The survey was made to provide data for the improvement of the sizes of ladies' ready-made garments. The necessity for such an inquiry is illustrated in the early part of the book by some results from an investigation into the actual dimensions of garments compared with their marked sizes.

This Dutch inquiry bears some resemblance to the American inquiry of 1939/40 and the corresponding investigation in this country recently carried out by the Clothing Industry Development Council, since all three are concerned with providing information on body measurements with special reference to the clothing trade. But the method of approach is different. The Dutch survey concentrates throughout on the practical aspects of providing garments that will fit. This underlies the decision to take tailoring measurements rather than those capable of anthropometric definition. A further consequence of this different approach appears in the method by which the authors decided which were the best variables to use in predicting the rest.

The sample of 5,000 women from 18 upwards was drawn from the customers of the Amsterdam, Rotterdam and The Hague branches of a department store. It is doubtful whether it is ever practicable in a survey of this type to select a strictly random sample and no pretence is made of doing so in this case. For the purposes for which this survey was carried out, the selection of a sample from retail shops, if not ideal, has much to recommend it. With suitable publicity the right type of individual will be available in numbers that are sufficient to keep the staff of measurers and recorders reasonably well employed. This is an important consideration, because an investigation of this type requires not only a small staff but also a certain amount of equipment and accommodation. Moreover customers of retail shops are the very people whom an inquiry of this kind is designed to help.

For each woman, weight and 14 body measurements were ascertained together with a few personal details such as age and economic status. All measurements were taken with the subject clothed but without shoes or coat. Measurements on fully clothed subjects have two advantages, co-operation is improved, and the resulting data are immediately relevant to the problems met

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with in making up garments and the choice of the right garment at the retail stage. On the other hand, many measurements taken in this way have the grave disadvantage that they are difficult to define and difficult to measure with precision. An analysis of repeated measurements on the same subjects indicates that for certain items, of which one is one of the two variables defining the recommended sizing system, as much as one-sixth to one-fourth of the observed variance was due to error in measurement. In this report all the observed correlation coefficients have been increased to allow for the reduction caused by this factor.

The authors of this book have gone further than others in working up their data in a form which is relevant to those who may use the results for sizing schemes. Their principal concern is not with the anthropometric problem of explaining or predicting body measurements as accurately as possible from one or more basic measurements, but with the construction of a system of sizing. To determine the choice of variables on which the system shall be based and from which the others shall be calculated they bring in two factors additional to the relationships between body measurements: firstly the tolerance that can be allowed each measurement within which the wearer obtains a reasonable fit, and secondly the cost incurred in making alterations to those garments which, although made according to the proposed system, do not in one particular or other fit the individual within the tolerance allowed.

The decisions reached were therefore the consequence partly of the fundamental body structure, partly of the properties of the garments in question and of the materials of which they were made, and partly of the assumptions made about the economic loss sustained in altering those garments which did not fit. The need for alterations to some garments arises because it would be uneconomic to make garments for all possible cases owing to the wide range of variation in body measurements. Therefore, in a proportion of cases, it would be necessary for purchasers to take garments which did not give a satisfactory fitting in some particular dimension and have them altered accordingly. From these principles the authors concluded that for the particular selection of measurements they had taken in the inquiry, waist girth was the best single predicting measurement, while waist girth and back length were the best pair.

This decision is in marked contrast with the findings of the American inquiry, in which it was concluded that women's body measurements were best described by weight and height. Viewed as anthropometric data without the additional consideration of tolerances and cost of alterations, a similar conclusion would have been reached in the Dutch investigation. In some respects this survey was less comprehensive than either of the American or British inquiries. The former was limited to weight and 14 body measurements. Four of these were in the nature of supplementary measurements; two relating to the foot and two to the hand. The American survey covered over 50 items and the British almost 40, all of which were taken either in foundation garments or with a special costume designed to provide close approximations to skin measurements.

The presentation of the results and the description of the inquiry, although rather long, are excellent. There is an English summary, and the value of the material in the book to those who know little Dutch is enhanced by a list giving the English translations of the captions of all figures and tables. The latter provide a fairly complete analysis of the data, including tables of multiple correlation coefficients and standard deviations with a single variable or a pair of variables held constant. The reviewer would personally have welcomed tables of the more important partial correlation coefficients, but these may, of course, be calculated if required from the data already set out in the tables.

W. F. F. KEMSLEY.

9.—*The A B C of the Foreign Exchanges.* By Norman Crump. 11th ed. London: Macmillan, 1951. viii + 403 pp. $7\frac{3}{4}''$. 12*s.* 6*d.*

Mr. Crump has a gift for realistically describing how the financial world works, and what might easily be difficult reading becomes at his hands simple and at the same time adequate. For all its familiar style of writing, this book gives a better and more accurate indication of how the foreign exchanges actually operate than more pretentious volumes.

This particular edition, the eleventh of the series begun in 1892 by Mr. George Clare but the first to appear since 1936, seems with unnecessary modesty to have dropped the claim to be "a practical guide". That is because of the great bulk of official regulations and of the difficulty of keeping abreast with their changes. The book is none the less as full and as practical as can be expected in a work of moderate length, nor is the author to blame if the chapters on the I.M.F. and on developments in the immediate post-war years seem disproportionately long in the light of present-day conditions. The earlier chapters, showing how the foreign exchange market worked before the war, are said in the Preface to be included because the controls have been built upon pre-war foundations—a view fully vindicated by recent changes in monetary policy and the resumption of a free market in forward rates. The sections on forward exchange and on the broker's

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functions, which only a year ago would have seemed merely nostalgic, have now taken on fresh interest.

Treated as a whole, the book provides a good general account of the way the foreign exchanges work in this country and of the institutions affecting them directly or indirectly. It is neither a banking manual in the narrowest sense (though the essentials of foreign exchange arithmetic are fully explained), nor an economic textbook of the highest academic standard. Mr. Crump is not afraid of making comment, but he does not set out to be a theorist, and some of his opinions may not seem quite as authoritative as the sections which are purely descriptive.

The previous edition has been skilfully revised and compressed into the first twenty-two chapters out of the fifty in the present book, the rest of the volume being quite new. After a short and elementary account of the exchanges generally, there follow several chapters on their technical operation before the war, a description of British financial institutions and their connection with the foreign exchanges, and accounts of the devaluation and the setting up of the E.E.A. in the 'thirties. War-time developments are then discussed at some length and shown to lead up to the present framework of exchange controls, almost half the book being devoted to a description of these controls and of post-war financial agreements of various kinds.

While such a structure seems logical enough at first sight, the value of the book appears to have suffered from the grafting of the new on to the old. The arithmetic and technical detail of the first few chapters are as necessary as ever, for to become completely at ease with the subject requires a particular type of mental gymnastics for which the drill hardly changes with the years. But these chapters seem imperfectly linked with the account of present-day controls. The reader may therefore feel with a little disappointment that he has been given a history, or the materials for a history, of exchange mechanisms rather than a clear description and analysis of the fundamentals of the foreign exchanges as they exist at present. Yet the book suggests that nobody is better qualified than Mr. Crump to describe intelligibly what really goes on in these mysterious and complicated markets.

M. S. Rix.

10.—*Lessons of the British War Economy*. Edited by D. N. Chester, National Institute of Economic and Social Research, Economic and Social Studies. Cambridge University Press, 1951. xii + 260 pp. 9½″. 22*s*. 6*d*.

We are told by biologists that further evolution must be expected to take the form not so much of physical development of our bodies as more scientific analysis of events, better transmission of ideas and improvement in social and economic organization. Whatever its desirability, there is no doubt that much of the development of the latter kind tends to take place under the aegis of the State and that it is accelerated by war. Not all of the many developments in economic organization that took place in the last war were transitory; some of them have survived into peace-time, and if a similar emergency should occur again we must expect that the arrangements to be made then will be largely based on previous experience. Obviously, the lessons of the British economy in the last war merit the closest study, and from this as well as from other standpoints it has been fortunate that some of the men concerned with the development and running of the war machine were university economists who, when it was all over, were eminently qualified to analyse their experience and expound the lessons to be drawn. We are indebted to the National Institute of Economic and Social Research and to Mr. Chester, for seeing to it in the present volume that the opportunity for presenting some of these lessons has not been missed.

The volume does not attempt a complete account of the whole economy. For example, nothing is said about the types of contract adopted and the methods employed for controlling costs and profits, although the contractual relations between the Government and industry were of the greatest significance for securing efficient production and for keeping down prices—the reason for this gap may be that this was a field into which few dons happened to penetrate. Nor have the various contributors to the volume been constrained to a single pattern of presentation; each deals in his own way with what he regards as important. But the result is an analysis, both interesting and penetrating, of most of the main features of the war economy.

The first few essays describe the central machinery of Government—Mr. Chester dealing with the system of Cabinet Committees and the work done by the Economic Section, Mr. MacDougall with the Prime Minister's Statistical Section, and Mr. Weeks with the machinery for liaison between the British and the Americans. Besides discharging the more formal parts of their task, these writers succeed in conveying very convincingly the atmosphere in which the makers of general economic policy worked. Professor E. A. Robinson surveys the machinery for overall allocation of materials and manpower, and his contribution is notable for its dissection of the main problems of war-time economic control and of the part played by statistics in solving them.

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The rest of the essays deal with more specialized fields. Mr. Stone, in the only essay on a purely statistical subject, recounts the development of national income statistics and their uses during the war, and goes on to indicate the main lines of post-war progress in this field. Professor Devons draws from his experiences at the Ministry of Aircraft Production the conclusion that complete overall planning and co-ordination by a central directorate is impossible. Certainly, readers who have worked in a planning directorate will appreciate his account of the subterfuges necessary to co-ordinate recalcitrant colleagues in other divisions of the same Ministry, and will sympathize with the planners' difficulties when it was found necessary to try to persuade firms to arrange production according to the programmes, and not according to the contracts which the firms had received from other divisions of the Ministry. An excellent picture of the control of building operations is given by Professor Bowen, and the allocation of timber is well described by Professor Ford. Professor Pares' description of the work of a Departmental priority officer supplements the picture of the overall allocation of resources given in other essays. Professor G. C. Allen describes the Board of Trade's concentration of industry policy, and Dr. Menzies Kitchen tells of the local administration of agricultural policy. A thoughtful analysis of the technique of rationing is made by Mr. Reddaway, and the history of the war-time control of food and agricultural prices is given by Professor Nash. Anyone interested in the difficulties that can arise in maintaining the strict objectivity of a statistical measure that records movements of major policy significance will no doubt ponder over Professor Nash's description of what happened to the old retail price index after the effects of applying subsidies to certain judiciously chosen commodities had been realized.

It is widely recognized now that national controls have to be largely based on statistics, but keener appreciation of this truth before the outbreak of the last war would undoubtedly have speeded the marshalling of resources. As many of the essays show, progress in most fields in 1940 and even in 1941 and 1942 was hindered by lack of the statistics necessary to appreciate the true position. Some statistical organizations were reduced at the outbreak of war, and it took one or two, and in some cases three, years before urgently needed information about manpower, materials, fuels, national income, machine tool capacity, factory space, etc., could be provided.

Whether it would have paid to prepare detailed plans for the allocation of resources in readiness for a possible war is arguable. It would have been quite impossible in 1939 to forecast the way the enemy attack developed or to assess the resources that would be at our disposal, and any balancing of the requirements of the Forces against the minimum needs of the civilian sector would certainly have turned out to be grossly in error. On the other hand, such work would have clarified the main issues involved and ensured an early start in the collection of information. Whatever the merits of the arguments on this particular question, what is much more certain is the benefit to the war effort if an earlier start had been made with the collection of the key statistics required for national control. Anyone who has had to introduce new national statistics will know that designing, printing and issuing returns takes many months, and that two years may easily elapse before they are being rendered satisfactorily and summarized efficiently and before their significance and limitations for practical use have been grasped. At a time when rapid appreciation of the situation and speed and flexibility in the deployment of resources may be essential for survival, delays of this order of magnitude cannot be treated lightly. It was perhaps as well that, in the Second World War, the offensive against this country developed comparatively slowly. We could not count on having as much time in another emergency. So far as statistics are concerned, the chief lesson to be drawn from past experience is the need to maintain key figures in being, and, if war clouds appear, to take the earliest practicable steps to develop any essential new statistics that are likely to be required.

It is true that national statistics are in much better condition now than they were in 1939, but it would be sanguine to suppose that their mere maintenance in future will be sufficient to deal with all emergencies. A matter that was inadequately dealt with throughout the last war was the correct geographical location of work in relation to manpower and industrial capacity. There was a constant tendency to overload some parts of the country and underload others, even though it was obvious that resources could not be spared to build new houses and to move labour about. There was a similar tendency to give too much work to the large contractors instead of issuing more direct contracts to small firms and stimulating the placing of sub-contracts. Inadequate breakdown of the necessary statistics on a uniform geographical basis was one reason for this weakness. Are our statistics better in this respect now?

G. H. DANIEL.

11.—*Corporate Income Retention* 1915–43. By Sergei P. Dobrovolsky. New York : N.B.E.R., 1951. xx + 122 pp. 9″. $2.50.

This is one of the studies in Business Financing that were initiated by the National Bureau of Economic Research. It is an attempt to relate income retention to such factors as profitablity

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and asset expansion in the varying circumstances of the years from 1915 to 1943. By the use of numerous charts the information that has been collected from the data available is clearly set out, and in each case the arguments pointing to the relationship of the particular factors under consideration are followed by a concise summary of the conclusions that the author has reached.

Briefly, these conclusions are that retention of income did not as a rule begin below a certain level which was found to be about 5 per cent. of the net worth of the company. Above this point a movement in either direction in net income of 1 per cent. of net worth usually resulted in a similar movement to the extent of 0·7 to 0·8 per cent. income retention and 0·2 to 0·3 per cent. dividend. Although it was found that retention was affected by the rate of asset expansion, the amount of reserves and surplus, and the previous year's dividends, it is only in the case of the last named that any consistent relationship was found to exist.

Dr. Dobrovolsky first considers the retention of income at various net income levels, with all manufacturing corporations as the basis ; the close relationship of these two is traced through the cycles of the period, rise and fall of the one being closely followed by the other. Against these have been indicated the dividend payments, with a similar trend, but far less marked in its movement. The following chapter treats separately a group of large corporations and then groups of small and medium-sized corporations. The former are considered in greater detail, and the effect on income retention of dividend requirements and of the rate of operating asset expansion leads to a detailed analysis of income retention of about 70 large corporations. It traces the degrees to which retention was carried out by companies with varying profitability, and concludes that retention was dependent upon previous dividend rates, and was more consistent amongst all the companies when this was taken into account.

The effect of undistributed profits tax that was utilized in America during the middle thirties is apparent, but there is considerable variance in this, and the treatment that its introduction and repeal were given by some of the companies ; there is doubtless a similar variance in this country to-day where there exists a higher rate of tax on distributions.

The changing value of money must have its bearing upon this subject. Its effect would have been more pronounced in the period following that covered by this book, but even in periods of minor change it cannot be ignored. In the appendix, the valuation of stock in times of rising or falling prices is discussed, and it is concluded that the preferable treatment is to take the stocks into account at their stated value, and not to adjust them to show only the physical increase or decrease during the year. In a time of inflation, if stocks are kept at the same physical quantity, income retention will be necessitated. Moreover, management will tend to retain profits to a greater extent because of the future if all replacement is to be more expensive. It is unlikely that profits will have been inflated to the same degree as costs, and Dr. Dobrovolsky has shown that dividend movements are less marked and frequently lag behind. A much higher retention would be expected under these conditions, and this being so, if the year-to-year trends are to be related, some method of eliminating the fluctuations in monetary values is necessary. These short-term trends are not considered in great detail as being outside the scope of the study.

The later chapters are devoted to the sources of financing corporate expansion, and the consideration of corporations in groups according to their size has proved of assistance in bringing to light different results ; the savings of large corporations were in excess of their needs, and were being utilized to finance the small and medium sized concerns during some of the periods.

Over nearly twenty years the net expansion of physical assets was found to have been financed on balance by external sources alone, since all the corporations dissaved over the period. The effects of business cycles were significant here, both in general and in the cases of those corporations grouped by size. The years of high expansion rates always resulted in high demands upon external finance, but the ratio of internal to external financing is subject to considerable variation.

Dr. Dobrovolsky has set out a considerable amount of information in a very compact manner. If the use of charts and tables has been liberal, it has added much to the clarity of the information put forward and the reasons for the conclusions that have been reached. Two main points emerge. Despite annual fluctuations and variance between companies, a constant relationship between net income and retained income exists, and if corporate income continues at a high level, much of the financing will be provided by retention of income. Only in periods of asset expansion is external finance required. The information provided also goes some way in the matter of the supply of funds for asset expansion, but this is dependent upon further factors than the trends of income retention.

I. G. BUTLER.

12.—*The Population of India and Pakistan*. By Kingsley Davis. Princeton University Press, 1951 (London: Oxford University Press). xvi + 263 pp. 12″. 48*s*.

Mr. Davis has fulfilled most admirably his self-allotted task of bringing a "fresh mind" to bear on the population statistics, problems, and experience of a region about which, as he himself

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says, he knew little when he started. His object was to explore and analyse the population problem of India and Pakistan theoretically, statistically, comparatively and in the context of social organization and social change, and finally, to estimate future population trends and their probable consequences. His book is a joy to handle, excellently printed and produced, and provides a mass of clearly presented and illuminating information, much of which takes the form of statistical tables, maps and figures, both scattered throughout the text and in Appendices which contain the bulk of his actual computations. Mr. Davis gives his readers full measure. He does not confine himself to purely demographic data, but, by means of concise historical and sociological excursions, gradually builds up a picture of the environment which places the population problem in true perspective as one aspect of the whole story of Indian social development. His text, and his bibliography, will therefore prove of interest and assistance to a wide public and not only to demographers.

The scope of the volume is necessarily very wide. Starting with a sketch on a large canvas of the story of the accelerating growth of population, the author proceeds to analyse seriatim the "fight against death," factors affecting fertility, the net balance of natural increase, migration movements, social structure and changes therein, after which, on the basis of his estimates of future trends, he discusses possible population policies and their practicability. The reviewer can, therefore, do little more than select special points, illustrative of Mr. Davis's work and methods, for commendation and (occasionally) criticism.

To take the criticisms first, it may be said that the later chapters, specifically Chapters XX–XXII, are less satisfying than those dealing with more purely historical and demographic topics. For instance Chapter XX, "Population and Partition," hardly touches upon the post-partition migrations between India and Pakistan, and their results. I note the absence of reference to Professor C. N. Vakil's *Divided India* (1950) which deals fully with this subject, but probably this book and other data on the subject were not available when Mr. Davis wrote. A much more serious omission (Chapter XXI, "Economic Achievement: Population and Agriculture") is the lack of reference to Mr. V. K. R. V. Rao's estimate of the National Income ("The National Income of British India, 1931–32", 1940), which was much the most careful estimate until the quite recent one made by the National Income Committee for the Indian Union.

Mr. R. C. Desai's estimate of consumer expenditure between 1931–32 and 1940–41 is also overlooked (*Journal of the Royal Statistical Society*, May, 1948), although this is of great importance from the point of view of trends, as it deals with ten consecutive years on the same basis. Again Mr. Davis has made no use of the *Eastern Economist*, whose Annual Numbers provide various statistical series for recent years, although it is not always easy to gauge their basis and accuracy.

In general this chapter is insufficiently up-to-date, and not as reliable and illuminating as most of the others. For instance, it is misleading to discuss average crop yields without referring to the presence or absence of irrigation. Indeed "irrigation" receives quite inadequate treatment throughout, and does not even figure in the index. The treatment of a number of topics ends at 1939; for instance, no mention is made of the war-time reduction in agricultural indebtedness. Chapter XXII, "Economic Achievement: Population and Industrialization", similarly pays too little attention to war-time and post-war developments.

First and foremost amongst the particular points for which unstinted praise is due is the general treatment of the available statistical data, whose unreliability and incompleteness is fully recognized. No attempt is made to use refined statistical techniques for material which could not stand the strain. On the other hand, the author takes nothing for granted. He re-works, re-classifies, and wherever possible improves upon and checks the methods of analysis and interpretation hitherto utilized. Estimated birth-rates and corrected death-rates are quoted side by side with the (acknowledgly deficient) recorded birth- and death-rates. The figures for Burma are eliminated throughout to provide comparable series before and after 1937. Future population trends are projected on three different bases (with alarming results!). Two new life tables have been constructed (*vide* pp. 35, 36 and Appendix C), and the existing tables have been criticized. Striking diagrams have been constructed illustrating the age structure in India and in other countries (*vide* p. 85, *et seq.*). In Appendix B the death-rate from influenza, in 1918–19, has been computed anew.

Mr. Davis's warm appreciation (p. 4) of the "imaginative and thorough" work of the many scholars who have helped to compile and interpret the results of the Indian Censuses is most welcome. It is sometimes forgotten how much sound, illuminating and fascinating historical and sociological material (of very varied types) is embodied in these official and externally forbidding tomes.

In general, although Mr. Davis has added relatively little that can be called "new", and his use of demographic material as a rule supports prevalent authoritative views and interpretations, his work must be regarded as a great achievement, not only because he provides a critical and

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well-balanced survey of the whole subject, but because of the objectivity and freshness that he has brought to his task.

In conclusion it may be of interest to summarize his assessment of the problem and of future possibilities. "Countries like India and Pakistan", he says, "face the question of (*a*) how to stop population growth before a rise in mortality automatically stops it, and (*b*) how to lower mortality still more without defeating this aim by a corresponding rise in numbers" (p. 223). He dismisses emigration (on an appropriate scale) as impracticable, and concludes that birth-control (even if adopted by certain sections of the population) may be expected to meet with serious opposition on both religious and moral grounds (p. 229). Rapid industrialization as an alternative to birth-control, as a means of checking population growth, is both more difficult and slower. Ideally, he suggests, three measures should be adopted concurrently, in order to maximize real income: i.e., "a program of strategic emigration, a sustained and vigorous birth-control campaign and a scheme for rapid industrialization" (p. 230). There is, however, little likelihood that a comprehensive population policy of this type will be adopted, whilst industrialization will probably precede any effective check to population growth, so that the situation "will get worse before it gets better" (p. 231).

It seems difficult to reject this gloomy conclusion, but it is better to face facts and work for the distant future than to risk disillusionment and indefinite postponement of a solution. Mr. Davis is to be congratulated on setting forth the facts so clearly and comprehensibly.

VERA ANSTEY.

13.—*Poverty and the Welfare State*. By B. Seebohm Rowntree and G. R. Lavers. London : Longmans, Green, 1951. viii + 104 pp. 7½″. 7*s*. 6*d*.

When one of the pioneers in the social survey field has the good fortune to be alive and active enough to repeat a survey he first made half a century ago it surely is an event to be hailed with delight. The York survey has been twice repeated and catastrophic wars have punctated the intervals between the three surveys. It will suffice in this review to compare conditions in 1936, the date of the second survey, and in 1950.

In one notable respect a new departure has been made. Whereas every working-class family in the city, so far as possible, was visited to get the particulars the investigators sought in 1900 and 1936, a sample of only one house in every nine was chosen for investigation from all streets inhabited by working-class families in this third survey. It is encouraging to find that Mr. Rowntree has convinced himself that strict random sampling, properly planned, will give results correctly representative of the sampled population to any degree of accuracy desired. This he did by the best possible method. Using his second survey material, he took from it random samples of one in 10, 20, 30, 40 and 50 schedules, and noted how far the results obtained from these successive samples agreed with the results of the complete house-to-house census based on the totality of samples.

The definition of a working-class house in 1936 had been one in which the chief wage-earner was earning not more than £250 a year. In 1950 the upper limit of working-class earnings was fixed at £550. An income of this amount was taken as equivalent to £250 in 1936, after " seeking the advice of persons competent to judge". We are not told who these persons were, but there is no reason seriously to dispute the figure. Mr. Rowntree's personal standing in the city of York goes far to account for his remarkable success in eliciting direct information from employers as to the earnings of over 95 per cent, of the heads of households chosen for investigation. The figures used were *net earnings* after deduction of income tax and National Insurance contributions. In 1936 these contributions were included under Personal Sundries.

The next step, as in his previous surveys, was to estimate the least sum required by each family, taking into account its size and composition, to purchase what was essential for healthy living. Trifling modifications of the diet prescribed in 1936 had to be made to allow for rationing, subsidies, school milk, etc., keeping the total nutritive value at the same time almost unchanged. The prices of foods included in the weekly menu were ascertained by inquiry at a number of shops catering for working-class people. The minimum expenditure on the food needed to keep Rowntree's standard family of husband, wife and three children at 1950 prices was thus found to be 47*s*. 4*d*. as compared with 20*s*. 6*d*. in 1936.

A departure from the 1936 procedure is to be noted in estimating the minimum cost of clothing. In both years the estimate was based, not on the experience of a random sample, but on that of a small carefully selected sample of men and women. In 1936 *the dozen closest estimates* of the minimum expenditure on women's clothing varied between 1*s*. 6½*d*. and 2*s*. 4½*d*. a week, and the estimate adopted was 1*s*. 9*d*., taking *no account of repairs*. In 1950 twenty-nine women were interviewed. Their annual expenditure covered a very wide range, and in view of this the authors considered that it would be misleading to base the new poverty line on their average expenditure,

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11*s*. 4*d*. a week. Accordingly the average of the figures of three women *who had spent least* was taken, which gave 5*s*. 2*d*. a week, and *this included repairs*. The same procedure was adopted in estimating the minimum cost of men's and children's clothing, fuel and light, and household sundries.

In 1950 net earnings, as already determined, were compared with the estimated minimum expenditure, excluding rent, which defined the Rowntree Poverty Line for any given family. For his standard family of five persons this line was drawn at a total of £5 0*s*. 2*d*. in 1950 as compared with £2 3*s*. 6*d*. in 1936. It may be observed incidentally that the increase is of the same order of magnitude as that adopted by the authors in defining their new upper limit of working-class earnings. Poverty, thus measured, was found to be relatively insignificant in 1950. In 1936 17·7 per cent. of the total population was in poverty, in 1950 only 1·66 per cent. If attention is confined to the working-class population, the decline was from 31·1 to 2·77 per cent. This can be attributed in part to the policy of full employment adopted as a post-war measure. Had unemployment remained at the 1936 level, other things being equal, it is estimated that the proportion of the working-class population in poverty would have risen to 7·85 per cent. The other major factor accounting for the diminution of poverty has been the steady encroachment of the Welfare State into the territory of free enterprise. The authors estimate that, had the provision of welfare services remained as in 1936—and this without taking into account the effects of the National Health Service Act, housing subsidies, and the extension of rent restriction—the proportion of the working-class population in poverty would have been 22·18 per cent. instead of 2·77 per cent. Food subsidies and family allowances have both contributed to the raising of many families out of poverty. Without food subsidies it is estimated that the proportion of the working-class population in poverty would have been 13·74 instead of 2·77 per cent., and without family allowances the proportion would have been 5·97 per cent. In judging these separate effects it must be remembered that each has been calculated on the assumption that other things would stay unchanged, but in fact they would not. It follows that we cannot add up the separate effects to arrive at the combined effect.

Of such poverty as remained in York in 1950, by far the greatest cause was old age. It accounted for 68·1 per cent. of all poor people, the next most potent causes being sickness (21·3 per cent.) and the death of the chief wage-earner (6·4 per cent.). Old age had only taken third place in 1936; unemployment and inadequate wages, which together were responsible for 61·4 per cent. of all poverty at that date, were negligible in 1950. It should be added that the position of old people, as the authors point out, has been substantially eased as a result of the increase in the rates of retirement pensions which came into force after the above calculations were made.

For those who prefer detailed description to statistical analysis vivid pen pictures are appended of 30 selected families above and 16 below the poverty line. A further chapter shows the marked improvement which has taken place over the years in housing conditions, although 4158 working-class families, 23 per cent. of all so classed, continued to share houses in 1950 and 990 took in lodgers.

D. Caradog Jones.

14.—*Coastwise Shipping and the Small Ports*. By P. Ford and J. A. Bound. Oxford: Blackwell, 1951. 52 pp. 9″. 10*s*. 6*d*.

As Professor Ford recalls in his preface to this book, coastwise shipping has been referred to as "that little known trade", and the publication of this study is therefore particularly welcome. Its scope is wider than might be inferred from its title, for, after a brief historical sketch, it deals with the coasting trade as a whole, and gives for a recent year (1948) an analysis, by main trade routes and by commodities, of the coastwise tramp cargoes, which amounted to nearly 30 million tons weight.

This analysis derives from the returns of coastwise voyages made to the Ministry of Transport by owners of coasters, and the lower limit of 100 gross tons which is used means, broadly speaking, that estuarial craft have been excluded.

The assessment of the importance of coastwise shipping to the internal transport system of the country is most illuminating. The authors point out that, since the average length of haul for goods carried by sea is much longer than that for goods carried by rail, it is misleading to use only the weight of goods carried as a measure of the services rendered by each of these forms of transport; indeed much of the coal carried coastwise has a short rail haul from pit to port.

The authors thus estimate the ton-mileage of coastwise tramp traffic (excluding traffic where there is no alternative to sea transport) and in this way arrive at a figure which is nearly 30 per cent. of the ton-mileage of all railway freight traffic. These results are necessarily approximate; nevertheless, any refinement of method could hardly make a difference to the order of the results.

The records which were available include the outgoing and incoming coastwise traffic of nearly

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300 ports and the authors give a table of the traffic of some 100 separate ports, with a breakdown into the main commodities, the figures for the remaining ports being given in regional groups. They point out how remarkably the ports in any one area stand out either as originating or receiving ports, and how the traffic through the ports fits in with the industrial output or needs of the areas served by them. This part of the work is completed by a table, for each group of ports, of "market boundaries", average lengths of haul, and total ton-mileage of traffic handled. There is certainly material here to justify the authors' assertion "that coastwise shipping and the smaller ports form a coherent system of transport; that the small ports have specific functions to perform, sometimes as the principal export points for a local product; even where they are minor ports clustered round one or two major ones, their work fits into the tasks of the whole group".

"This study" says the preface, "attempts to . . . provide a firm statistical basis for a discussion of the problem (of coastwise shipping)". In reaching their objective, Professor Ford and Mr. Bound have not only provided valuable material for those directly concerned with the country's internal transport, but have also provided a lively account of the work of coastwise shipping which should have a wide appeal.

R. C. OADES.

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STATISTICAL NOTES

(1) British Official Statistics

The interim index of retail prices compiled by the Ministry of Labour and National Service rose from 127 in August to 132 in January, 1952. The food index rose by 10 points in this period. There were also increases in many items of clothing, and in the price of coal and cigarettes.

The detailed figures for August to January were as follows:

(*Prices at June 17th*, 1947 = 100)

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Household Durable Goods*	*Miscellaneous Goods*	*Services*	*Drink and Tobacco*	*Total*
Weights:	348	88	97	65	71	35	79	217	1,000
Aug. 14th	139·7	103·9	142·7	127·8	137·6	132·1	120·3	106·8	127
Sept. 18th	140·6	103·9	144·0	128·8	137·5	133·4	121·3	108·0	128
Oct. 16th	142·8	104·2	145·1	129·8	136·5	134·8	121·6	108·0	129
Nov. 13th	143·5	104·2	145·7	132·4	136·2	134·9	122·0	108·0	129
Dec. 11th	144·9	104·2	147·3	134·2	135·9	137·1	122·8	108·0	130
Jan. 15th	149·7	104·2	147·1	140·1	136·6	137·3	123·9	108·5	132

In publishing the figures, the Ministry of Labour states that they are in the form in which they are used in the procedure adopted in calculating the index for all the groups combined, i.e., to the nearest first place of decimals. The decimals are shown in order that, if desired, calculations can be made of the effect of combining particular groups and excluding others. The information available as to price changes, however, is such that no precise significance can be attached to the decimals, and for any other purpose, therefore, the figures should be used to the nearest whole number.

The Ministry of Labour index of weekly wage rates which was 120 (June, 1947 = 100) in August rose to 123 in September, 122 in October, 125 in November, 126 in December, and 127 in January. The figure for men rose from 119 to 125, that for women from 125 to 130 and that for juveniles from 126 to 133. The workpeople whose rates of wages were raised in this period included agricultural workers, coal miners, engineers and shipbuilders, and employees in the cotton industry, hosiery, road haulage, railway service, gas supply and local authority services.

The total working population and the numbers in civil employment between July and December were as follows:

(*Thousands*)

	Total Working Population			*Number in Civil Employment*		
	Males	*Females*	*Total*	*Males*	*Females*	*Total*
July, 1951	15,965	7,400	23,365	15,022	7,310	22,332
Aug., ,,	16,012	7,437	23,449	15,060	7,342	22,402
Sept., ,,	16,031	7,451	23,482	15,064	7,335	22,399
Oct., ,,	16 027	7,465	23,492	15,037	7,326	22,363
Nov., ,,	16,021	7,479	23,500	15,012	7,332	22,344
Dec., ,,	16,007	7,419	23,426	14,975	7,246	22,221

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The level of unemployment rose steadily between August and December from 204,884 to 302,956. The figures are analysed below:

Number of Unemployed Persons on the Registers of the Employment Exchanges of the Ministry of Labour and National Service

Date	*Men and Boys*	*Women and Girls*	*Total*
Aug. 13th, 1951	132,886	71,998	204,884
Sept. 17th, ,,	135,213	81,815	217,028
Oct. 15th, ,,	152,872	110,884	263,756
Nov. 12th, ,,	168,536	121,941	290,477
Dec. 10th, ,,	175,464	127,492	302,956
Jan. 14th, 1952	216,379	162,362	378,741

The figures do not include registered severely disabled persons who are unlikely to obtain work other than under special conditions.

It is estimated that the number of unemployed persons on the registers at January 14th represented 1·8 per cent. of the total number of employees insured under the national insurance schemes. The percentage in the Regions ranged from 0·5 in the Midlands to 2·9 in the Northern Counties, 3·3 in Scotland and 3·3 in Wales.

The number of insured persons absent from work owing to sickness, including self-employed as well as employed, was 766,900 in August, 806,500 in September, 865,500 in October, 857,700 in November and 802,000 in December. All these figures were lower than those a year earlier. The number of employed persons absent owing to industrial injury was 55,500 in August, 59,400 in September, 62,400 in October, 61,300 in November and 55,200 in December.

Statistics relating to the membership of Trade Unions at the end of 1950 became available in November. They show that a slight decline in 1949 was followed by another in 1950. At the end of the year there were 9,235,000 members of Trade Unions, 7,565,000 males and 1,670,000 females. The 17 largest Unions accounted for 6,116,000 of this total.

The second in the series of Guides to Official Sources (Census Reports of Great Britain 1801–1931) gives much-needed help towards the use of the many reports on the first fourteen decennial enumerations of the people of Great Britain.

The legislation authorizing successive censuses, the nature and range of questions asked at each and the reports subsequently published are dealt with in the opening chapter, which is followed by a synoptic view of the development of method and procedure. An outline is then given of the range of information obtained on twelve selected subjects of inquiry. Certain sections are accompanied by concise reference lists indicating in detail the content of relevant Tables in the Census Reports. A series of census schedules reproduced in the Appendices includes the hitherto unpublished schedule used in the 1861 Census of Scotland.

Though the aim of the guide is chiefly to assist research workers, there is much in it of interest to statisticians in general, and even to the merely curious. Chapters II to IV, for instance, which are historical, recall to life the conditions in which Parliament legislated, civil servants drafted procedures and schedules, and enumerators went their rounds, especially at the earlier dates, so that the reader is unexpectedly left with an impression of the British people each time they were counted, as well as with clear notions of how and why each count took place.

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(2) Other Statistics

Statistics in Local Government almost invariably mean financial detail. It is therefore exceptional to look through the *City of Birmingham Annual Abstract of Statistics, No.* 1, 1931–1949 (City of Birmingham Central Statistical Office, 1951, 15*s.*), a statistical publication covering the affairs of a local authority, and to find no reference to the rates levied, the net loan debt or similar aspects of the Treasurer's responsibilities. This absence of financial data reflects the origin of the abstract, which has been compiled by Dr. Padley, the Deputy Chief Statistical Officer of the City of Birmingham Central Statistical Office. Dr. Enid Charles (the Chief Statistical Officer) explains in the foreword that the object is to present all statistical material about the

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health and welfare of the City's population. This object is well achieved within the scope of 14 chapters, beginning with population and vital statistics and finishing with meteorology. The early chapters contain much detail about the population, births, marriages, deaths and the health of the citizens. Housing and its associated interests are followed by a dozen tables on education. Chapter 6 under the title of "Judicial and Protective Services" consists of statistics about the police force and the fire service. The next chapter, however, is devoted to the "Care of Children", which, being essentially a protective service, would have been more logically presented as a third section of Chapter 6. Miscellaneous services, e.g., parks, baths and libraries, comprise a further separate chapter. After transport and communications, and public utilities, Chapter 11 on employment and industry is the largest of all with 23 tables. Two very brief chapters, one on government and the other on climate, complete this pioneer abstract. Three maps and nine charts illustrate selected subjects; these serve their purpose very well, with the exception of the diagram on indictable crimes on p. 92.

When so much statistical material is collected and published on a national scale, there is a danger that information relating to local areas is neglected. It is therefore the more pleasing to see in this volume such an impressive range of statistics for a local authority. The Central Statistical Office of the City of Birmingham is to be congratulated on the preparation and publication of this abstract.

The Department of Economic Affairs of United Nations has recently issued a number of reports on economic conditions in the world and its principal regions. The *World Economic Report*, 1949–50 (250 pp., $2.50) continues the survey of current economic conditions of its predecessors. It describes first the development in national economic conditions and economic relations during 1949 and the first half of 1950, followed by an analysis of the changes in the volume and direction of international trade and of trends in international financial settlements. A final part is devoted to a discussion of the factors underlying the present dollar deficits and of the relationship between the devaluations of 1949 and the changes in international trade. It is impossible in a short notice to summarize the conclusions of this comprehensive survey; it contains a mine of information on all national and international aspects of economic conditions in the different parts of the world, and is lavishly supplied with statistical tables.

This volume is completed by two supplements, issued separately, the *Review of Economic Conditions in the Middle East* (84 pp., $1.00) and the *Review of Economic Conditions in Africa* (119 pp., $1.25). The first report outlines the basic physical social and economic characteristics of the region, and the main economic trends which have appeared since 1949. A special chapter is devoted to the oil industry. The volume contains valuable maps of the region illustrating transport routes and petroleum areas, and a statistical appendix of 50 tables to supplement and amplify the data in the text. The low living standards of the region and the limited interchange among the mass of the population are cited as factors which keep the demand for foreign and domestic goods low.

The second supplement (on Africa) is the first issue of a separate survey for this region. It covers the whole continent (except Egypt, considered part of the Middle East). It describes the basic characteristics of Africa, analyses recent economic trends and gives an account of the various plans for its economic development. A remarkable amount of statistical data, most of it assembled for the first time, is presented, and it is doubtful if any other body than the United Nations, by its close co-operation with its specialized agencies and governments, could have produced so complete and up-to-date an account of the economic conditions of the "Dark Continent".

The *Economic Survey of Asia and the Far East* 1950 (534 pp., $3.75) is issued as an independent volume as it is the work of the United Nations Economic Commission for this region. It follows largely the lines of the volume for 1949 reviewed recently in the *Journal* (Part I, 1951). Special chapters are given on the resources, income and economic development problems and trends, followed by a review of the developments of the current year in agricultural and industrial production, transport, international trade and payments, public finance, currency and prices. The impact of the Korean war and of rearmament brought a superficial wave of prosperity to many parts of the region but this is considered to be no stable basis and, chiefly owing to political causes, the position to be one of grave anxiety.

The *Economic Survey of Europe* 1950 was reviewed in this *Journal* (Part IV, 1951).

Apart from Latin America, for which no recent survey has yet been issued, these five volumes constitute a noteworthy, and a praiseworthy, account of the basic economic conditions in the world in 1949–50, written with an objectivity which is characteristic of the United Nations' Department of Economic Affairs.

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Recent statistical publications of the United Nations (Statistical Office) are first the *Year Book of International Trade Statistics* 1950 (174 pp., $1.75). In pre-war years the League of Nations issued annually from 1933 to 1939 a volume entitled *International Trade Statistics*, and the present volume is the first to be issued since that time. The countries covered are not quite as numerous as those of the pre-war volumes; 42 are included, and for each of these countries four tables are given: a historical summary covering, as far as possible, the years 1930 to 1950, of value of trade both in national currency and in gold, together with index numbers (1937 = 100) of quantum and unit real value; principal commodities imported; principal commodities exported; trade by principal countries of origin and destination. The list and order of commodities are those used by the country itself and not those of the standard classification adopted in 1950 (see below). The method of construction of the indexes of quantum and unit value are briefly described and the formulae used indicated.

The *Standard International Trade Classification* (Statistical Papers, Series M. No. 10 (150 pp., $1.50) is a reissue of a volume first published in 1950; its principal object is to show for each of the 570 items the corresponding items (by means of code numbers) both of the Minimum List of Commodities for International Trade drawn up by the League of Nations in 1938 and of the Tariff nomenclature recently prepared for customs purposes by the European Customs Union Study Group. The reverse coding of the latter list to the former is also given. These comparisons of the three lists by code numbers have been made primarily to give immediate assistance to governments in making comparisons of their national classifications with the Standard International Trade Classification, which was drawn up originally by the Economic and Social Council in order to promote the systematic analysis of world trade and a common reporting basis of trade statistics.

In the field of financial statistics, the United Nations (Department of Economic Affairs) has begun the issue of a series of *Public Finance Information Papers*, and the first five covering Egypt, Colombia, Italy, Iran and Irak have just appeared. Their object is to present a survey of the public finances of each country and its budgetary system, covering as far as possible the latest ten years. A series of appended tables summarizes the national accounts (expenditure, receipts, public debt and balance-sheets). Other volumes in the series are in preparation.

Finally, attention may be called to the *Economic Bulletin for Europe*, of which the issue for the second quarter of 1951 has recently appeared (94 pp., $0.50). This bulletin is published by the Economic Commission for Europe each quarter except the fourth, when it is replaced by the annual Economic Survey of Europe (see above). Each issue contains comprehensive tables of European statistics on production, prices and trade, a review of the economic situation in the preceding quarter and special articles. Those of the current number are devoted to recent developments in trade between Eastern and Western Europe and to long-term trends in European agriculture.

CURRENT NOTE

The Executive Committee of the London and Cambridge Economic Service has made arrangements for its Quarterly Bulletin to be published regularly in future in the March, June, September and December issues of *The Times Review of Industry*. The first issue of the Review to contain the Bulletin was that for March, 1952.

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OBITUARY

George Udny Yule, C.B.E., F.R.S.

The Yule family has roots reaching down deep into Scottish history. William Yule, the grandfather of George Udny Yule, was born in 1764, nearly two centuries ago. Although he published little, he was widely known for his extensive oriental learning, particularly his scholarship in Persian and Arabic. Of his three sons, Robert (1817–1857) was killed in action at Delhi, commanding the 9th Lancers during the Indian Mutiny. George (1813–1885) became distinguished for his administrative work in India, for which he was knighted. Henry, the youngest (1820–1890), who also received the honour of knighthood, was a man of many parts, whose edition of Marco Polo's travels is a definitive work exhibiting all the patient scholarship characteristic of his family.

George Udny Yule, the subject of this memoir, and one of several members of his family to bear the name, was the son of Sir George Udny Yule and the nephew of Sir Henry. The literary and administrative traditions of his family were strong behind him and were to influence him throughout his life; but through him they found expression in a new medium. He was born on February 18th, 1871, at Beech Hill, a house at Morham, near Haddington in Scotland, which was destroyed in 1944 by an aircraft crashing on it. (His second name derives from an ancestor of the family of Udny of that ilk.) After schooling at Winchester he proceeded at the age of 16 to study engineering at University College, London. There he spent three years as an undergraduate (1887–1890), and a further two years (1890–1892) in engineering workshops. But he seems to have felt that engineering was not his *métier* and in 1892 went for a year to Bonn, where he embarked on research into electric waves under Hertz. His first published papers (1893*a*, *b*, *c*, 1895*a*) were based on this work, but experimental physics failed to hold him any more than had engineering and he never again wrote on either subject. It does not appear, in fact, that this early training left a permanent imprint on his habits of thought. One would not suspect an engineering background behind his mature work; the only point at which it exerted some influence was in his careful and expert draughtsmanship and his preference for diagrammatic representation.

In the summer of 1893, at the age of 22, he returned to London, and was promptly offered a demonstratorship at University College by Karl Pearson, who was then Professor of Applied Mathematics and had known Yule as a student. Yule accepted the post, discovered in Pearson an inspiring teacher, and before long was himself making fundamental contributions to the theory of statistics (1897*a*, *c*, 1899). His long association with the Royal Statistical Society began with his election to fellowship in 1895; at his death he had been a fellow for 56 years. About this time he decided to make statistics his life's work and his career was firmly founded.

Although Yule was given the title of Assistant Professor at University College, the salary of such a post in those days was scarcely a living wage. Early in 1899 he left the College for secretarial work with an examining body (the Department of Technology of the City and Guilds of London Institute). This helped to provide bread and butter, but his interest in statistical work was undiminished, and he continued to publish numerous papers on association and correlation (1900*a*, 1901, 1903). Moreover, his relationship with University College was not severed. Between 1902 and 1909 he held, in addition to his post at the City and Guilds Institute, the Newmarch Lectureship in Statistics. During this period he gave an annual course of lectures on statistical method which formed the basis of his *Introduction to the Theory of Statistics*, the first edition of which was published in 1911. During his lifetime it ran to fourteen editions, and was to make his name known and respected all over the scientific world.

In the meantime he became (in 1907) an honorary secretary of the Royal Statistical Society, an office which he held for twelve years. The Society awarded him its highest honour, the Guy Medal in gold, in 1911. It was during the period from 1900 to 1912 that his basic work on correlation and association reached its peak (1907*a*, 1912); but his work was always practical, and these theoretical studies were accompanied by contributions to various economic and sociological subjects (1906*a*, *c*, 1907*b*, 1909, 1910*a*) as well as to Mendelian inheritance (1902*a*, 1907*c*, 1914).

The year 1912 was a turning-point in Yule's career. The University of Cambridge offered him a new post of lecturer in statistics. He accepted, and was duly appointed from October, 1912. There then began his long association with St. John's College, of which he became a member in 1913 and a Fellow in 1922, and where he resided for the rest of his life except during the last years of illness. He was to hold his University post, which was raised to the status of readership, until reaching the age of 60.

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The first world war interrupted his academic career and Yule spent four years (1915–1919), first as statistician to the Army Contracts Department of the War Office and then as Director of Requirements with the Ministry of Food. He never spoke to me of these years with any affection, but he must have performed his exacting duties efficiently for his work at the Ministry of Food was recognized by a C.B.E. in 1918.

In 1919 he returned to Cambridge. The war years had not been unproductive of theoretical research, and two papers (1915*a*, 1920*a*) written in collaboration with his lifelong friend Major Greenwood are notable contributions to methodology. The next ten years were to see the full expression of his genius: the papers on time-correlation (1921, 1926, 1927), in which he introduced the correlogram and laid the foundations of the theory of autoregressive series. Further honours came to him naturally, as his reputation was consolidated. In 1922 he was elected a Fellow of the Royal Society, and from 1924 to 1926 was President of the Royal Statistical Society. Various foreign societies elected him to membership and his book was officially translated into the Czech language.

During the 1920's Yule developed a keen interest in motoring, and scandalized some of his fellow dons by the speed at which he travelled. This led him on to an interest in flying, but yielding to some pressure he postponed learning to fly until his retirement in 1930. Then he found that, being over sixty, he was an unacceptable risk as a pilot, and no private company could teach him to fly one of its planes because of the lack of insurance cover. "So of course", he said to me afterwards, "I had to buy my own plane". He did so and acquired a pilot's flying certificate A in 1931, a feat of which he was secretly rather proud, as well he might be. Ten years later he and I were sitting together in the Fellows' garden at St. John's when a bombing raid was in preparation. The sky was throbbing with aircraft circling round Cambridge. Yule threw his head back and laughed in his hearty way. "I was just thinking", he said, "that I am licensed to fly every one of those things and I haven't the first notion about the controls of any of them".

However, his flying career was soon brought to an end. In 1931 his heart, which had never been very robust, gave serious trouble (there was, I think, a partial heart-block), and for the rest of his life he was a semi-invalid, alert enough in mind, but inactive in body, climbing the flight of stairs to his rooms only with some difficulty. This irked him considerably, and reacted to some extent on his work. He continued to give some lectures, mainly on vital statistics, as college lecturer until 1940, when he finally gave up teaching; but apart from the paper on vital statistics (1934) he produced very little between 1931 and 1938. He began to feel that the new developments in his subject had overrun him. The death of Karl Pearson in 1936 affected him deeply. "I feel", he wrote to me, "as though the Karlovingian era has come to an end, and the Piscatorial era which succeeds it is one in which I can play no part". In particular he refused to revise any more editions of the "Introduction", and it was a purely chance meeting between us in 1935 which led him to ask me to take over future revisions.

It was during this period that he enlivened an argument about the modern theory of small samples by some Latin verses, from which the following is an extract:

Nonne hoc mirificum?
Sicut sanctum templa
Attrahunt statisticum
Parvula exempla

Multas horas disputat
Mente laborante
Multas horas computat
Machina crepante

Agitat memoria
Multum verbum bonum
Machina scriptoria
Spargit mirum sonum

Plagula novissima
Tandem terminata
"Omnia clarissima"
Clamat "enodata"

Ai! inundor symbolis
Verbis longis tundor
Occaecor parabolis
Juppiter, confundor!

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O Exemplum Parvulum
Sero te amavi
Tecum lusi paululum
Mentem fatigavi

O aenigma lepidum
Nova pulchritudo
Vae! Ardorem tepidum
Vicit senectudo.

There is a good deal of the real Yule in this *jeu d'esprit*. The facility with medieval Latin; the sly references to the Dies Irae, and to St. Augustine's famous invocation to the Deity ("Sero te amavi, pulchritudo tam antiqua et tam nova, sero te amavi"); the legitimate scepticism of a practical statistician for the monstrous regiment of mathematicians; the genuine regret of a man who lived to see his subject opening up new pathways along which he could not hope to tread; and most of all, perhaps, the revealing fact that he felt regret rather than resentment.

I like to think that the publication of the revised "Introduction" in 1937 gave him a new lease of life. The first four editions of the book (1911–1917) had totalled only 2,750 copies, and the first ten editions (1911–1935) amounted to 12,250 copies, equivalent to an average sale of about 500 copies a year. The eleventh edition, of 3,000 copies, was exhausted in less than two years, and by 1950 the revised version (11th to 13th editions) had sold about 15,000 copies—an annual rate of more than double that of the earlier years. Since the war, in fact, the rate of disposal has been four times the pre-1937 figure. The increasing popularity of the book did a good deal to counteract Yule's feeling of being left behind by modern developments. He professed to be astonished that the work fulfilled his earlier hope that it would be useful to new generations of students, but he was undoubtedly greatly pleased and comforted.

However that may be, he resumed work and soon began to make further characteristically original contributions. Between 1934 and 1939 his publications were slight; they read like the work of a man who was tidying up his desk in preparation for retirement from the subject. But at long last the philological interests of his family began to show themselves. He became interested in doubts cast on the attribution of the *De Imitatione Christi* to Thomas à Kempis, and was led on to study the statistical characteristics of an author's style. His earliest attempts in this field were concerned with sentence length (1939*b*), and these alone were almost sufficient to dismiss a number of claimants to the *Imitatio* such as Gerson. His main work, however, related to the occurrence of words (principally nouns), and his researches found expression in his last book (1944) on *The Statistics of Literary Vocabulary*. As by-products he wrote a note on a textual emendation of Milton's *Areopagitica* (1943*a*) and two papers on errors in copying manuscripts (1946, 1947). These, I believe, were his last published works.

And so the man who has contributed as much as anyone to the true science of statistics, who began his career with a paper in the *Proceedings of the Royal Society* on interference phenomena in electric waves passing through an electrolyte, closed it with a study in a theological journal on the dating of families of manuscripts. He completed a concordance to the prayer-book version of the psalms, and was greatly disappointed at failing to find a publisher for it; but all further labour came to an end as his health grew steadily worse. His heart became less and less equal to its task and he spent the last two and a half years of his life in nursing homes, walking a little, reading a little, corresponding a little, but conscious that his powers were failing, and waiting, not always patiently, for the end. It came in his eighty-first year on June 26th, 1951, in the Evelyn Nursing Home at Cambridge.

A great deal of Yule's contributions to the advancement of statistics cannot come to light; they reside in the stimulus he gave to his students, the discussions he held with his colleagues on a host of subjects, notably agriculture and demography, and the advice he freely tendered to all who consulted him, for he was always a most approachable man. Of his published work, also, the value of some of his contributions has been lost to view in sheer virtue of their success; for example, his work on correlation and regression is now such standard practice that only the student of history would consult the original papers. When all this is said, however, there remains enough in his bibliography to illustrate amply the breadth of his vision and the originality of his treatment. Fundamental ideas abound in his work, and are usually put forward in such a cautious way that the reader does not always appreciate their importance. It was Yule who gave, in the "Introduction," formulae on correlated sums which are still being rediscovered by students of systematic sampling. It was Yule who invented the correlogram, though he did not invent the name; and likewise it was he who developed the autoregressive series, though again, another invented the name. It was Yule who cut through several pages of Pearsonian algebra to point out that the sampling formulae for partials must be of the same form as those of total correlation

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coefficients in normal variation, and hence paved the way for Fisher's derivation of the distribution of partial correlations. Only in one respect has his name been attached to a statistical concept, the so-called Yule process; and if I had not chanced to mention it in casual conversation a few weeks before his death he would have died in ignorance of the fact.

The three requirements in a good detective, according to Sherlock Holmes, are knowledge, powers of observation, and powers of deduction. All these Yule had in abundance. He was not an expert mathematician, but his mathematics were always equal to their task. He possessed, in addition, extraordinary insight and a balanced judgment which earned him the respect and admiration of all who knew his work. Apart from a clash with Karl Pearson—which was scarcely to be avoided by any of his generation—his writings are exceptionally free from controversy and the personal embitterments which mar so much of the statistical literature of the past thirty years. It was not that Yule did not possess a temper or a set of decided opinions; he kept them, as he kept all his faculties, under control in the interests of the cause of science.

In character he was kindly, gentle and genial. His wide knowledge of many subjects and his love of an apposite story made him the best of companions. His correspondence was a delightful mixture of shop, anecdote and commentary on things in general, as the following random extracts will show:

"I began to keep a commonplace book many years ago, filled with quotations of rude things people have said about statistics. I gave it up as they became less and less imaginative . . . ".

"Isn't it extraordinary how difficult it is to get a sample really random? Every possible precaution, as it may seem, sometimes fails to protect one. I remember Greenwood telling me that, in some experiments done by drawing differently coloured counters from a bag, there seemed to be a bias against one particular colour. On testing, they concluded that this colour had given the counters a slightly greasy surface, so that it tended to escape the sampler's fingers . . . ".

"Egon Pearson sent me a few days ago a folder advertisement of *Who's Who*. The inside was headed 'People in the News' and there was given seven specimen biographies, Anthony Eden, Sir Patrick Hastings, General Smuts, Sir John Reith, Ellen Wilkinson, ME!!! and Sir Basil Zaharoff. Isn't this fame? . . . If any reporters do come to a paper of mine at the Stat. Soc. they soon rise up and walk out gently with bowed heads, moaning like the wind in the key-hole . . . ".

"I enclose a paper by Raymond Pearl. Here contraceptive methods appear to have brought about a reduction of some 20 per cent. for married white women—but an *increase* of some 14 per cent. among married negresses! . . . It interests me that you are sceptical as to the truth of the usual view that contraception depresses the birthrate. Willcox of the U.S.A. is about the only man I can recall who agreed with me. Almost all the others jeered . . . ".

"The college is suffering from a frightful insult from the A.R.P. authorities. They have put up a notice outside our back gate pointing to the Cam and saying 'Static Water' . . . ".

"Measurement does not necessarily mean progress. Failing the possibility of measuring that which you desire the lust for measurement may, for example, merely result in your measuring something else—and perhaps forgetting the difference—or in your ignoring some things because they cannot be measured . . . To my mind Freudian psychology made more progress in a few years than measurement-psychology had made for decades. Mendelism again meant more progress than Biometry . . . ".

"Gosset came in to see me the other day. He is a very pleasant chap. Not at all the autocrat of the *t*-table . . . ".

A man of Yule's age has the misfortune of seeing many of his friends and contemporaries precede him to the grave. Some are left to mourn him; far larger is the number of younger men who knew him first as instructor and then as friend and will always remember him as one of the ablest, kindliest and most lovable of men.

M. G. KENDALL.

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The book was then re-written by M. G. Kendall and re-set in a larger format, the new edition appearing under their joint names: 11th edn. 1937, 12th edn. 1940, 13th edn. 1945, 14th edn. 1950.

A very handsomely produced official translation into Czech was published in 1926, and an unauthorized Polish translation in 1921. Translations have also appeared in Spanish and Portuguese.

(2) 1944. *The Statistical Study of Literary Vocabulary.* Cambridge University Press.

In his will, Mr. Yule bequeathed to the Society all books, journals and pamphlets on statistical and economic subjects which might be in his possession at the time of his death, giving the Society complete freedom to sell at their discretion any copies which may already exist in the Society's library or which, for any reason, they do not wish to retain.

Furthermore, the Society and St. John's College, Cambridge, will eventually become entitled in equal shares to the residuary estate, subject in the meanwhile to three life interests.

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UNITED KINGDOM—

Accounting Research—

October 1951—The high-speed computer and the field of accounting: *A. Matz.* Double entry book-keeping in commercial accounting and in social accounting: *E. Fuerst.* Accounting principles: *F. Sewell Bray.* The integration of standard and current cost for profit measurement: *W. E. Spruce.* Measurement of national income and construction of social accounts for an industrially backward economy—I: *V. M. Dandekar.*

Annals of Eugenics—

December 1951—The goodness of fit of a single hypothetical discriminant function in the case of several groups: *M. S. Bartlett.*

British Journal of Social Medicine—

July 1951—Health of the schoolchild: *V. Norris.* Changing mortality from 1841 to 1947: *W. Taylor.* Observations on all births (23,970) in Birmingham, 1947. III. Survival: *J. R. Gibson* and *T. McKeown.*

October 1951—Measuring the risk of infection at work: *D. Hewitt* and *A. Stewart.* ABO groups of infants and children dying in the West of Scotland (1949–1951): *D. Struthers.* Sex ratio of stillbirths related to birth weight: *T. McKeown* and *C. R. Lowe.* Poliomyelitis in England and Wales, 1947–1950: *W. J. Martin.* Birth weights of South African babies. II. Effect of birth rank on birth weight: *E. J. Salber* and *E. S. Bradshaw.* Secular changes in the incidence of malformations of the central nervous system: *B. Macmahon, R. G. Record* and *T. McKeown.* Observations on all births (23,970) in Birmingham, 1947. V. Birth weight related to economic circumstances of parents: *J. R. Gibson* and *T. McKeown.*

Economic Journal—

December 1951—British and American exports: a study suggested by the theory of comparative costs. Part I: *G. D. A. MacDougall.* The declining economic importance of agricultural land: *T. W. Schultz.* Economic progress and occupational distribution: *P. T. Bauer* and *B. S. Yamey.* The Tucker Report and the technique of adjusting taxable profits for price changes: *K. Lacey.* Ideal output and the interdependence of firms: *L. W. McKenzie.* Public and private financing of industrial enterprise: *C. H. Sharp.* The taxonomic approach to economic policy: *H. G. Johnson.*

Eugenics Review—

October 1951—Recent investigations of intelligence and measurement: *P. E. Vernon.*

Geographical Journal—

September 1951—Economic development in Israel: *Sir C. Skrine.* Hydro-electric power in Western Europe: *A. F. A. Mutton.*

Incorporated Statistician—

November 1951—Some missing industrial statistics: *J. Ryan.* Biological experimentation: *J. Wishart.* Frequency distributions in British agriculture: *D. K. Britton.*

Institute of Actuaries, Journal—

Vol. LXXVII, Part II, No. 346—Personnel statistics and sickness-absence statistics: *F. H. Spratling* and *F. J. Lloyd.* Duplicate policies in mortality data: *R. H. Daw.* War deaths investigation.

Lloyds Bank Review—

October 1951—1947 comes again: *T. W. Kent.* The economic recovery of Western Germany: *A. K. Cairncross.* Some economic problems of Atlantic Union rearmament: *J. E. Meade.*

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Manchester School of Economic and Social Studies—

September 1951—Migration and the rhythm of economic growth, 1830–1913: *Brinley Thomas.* World trade in manufactured commodities, 1899–1950: *H. Tyszynski.* An investigation of hedging on an organized produce exchange: *B. S. Yamey.*

Manchester Statistical Society, Transactions—

Session 1950–51—The analysis of uses of cotton products: *A. C. Wild.* The methods by which the B.B.C. endeavours to measure viewing: *R. Silvey.* Some remarks on the theory of statistics: *M. S. Bartlett.* Recent developments in economic statistics: *C. Campion.* Free trade and modern economics: *J. R. Hicks.*

Oxford University Institute of Statistics, Bulletin—

November and December 1951—Earnings in shipbuilding: *K. G. J. C. Knowles* and *D. J. Robertson.* A "human needs" diet in November, 1951: *T. Schulz.* A note on Federal Reserve policy: *T. Balogh.* Personal incomes in Oxford: *H. F. Lydall.*

Population Studies—

November 1951—A study in miniature of Chinese population: *W. G. Skinner.* Differential fertility in Puerto Rico: *J. W. Combs* and *Kingsley Davis.* Urbanization in Malaya: *E. Cooper.* Studies in recent marriages and fertility data of England and Wales: *P. R. Cox.* The resettlement of Jewish refugees in Israel, with special reference to those known as displaced persons: *H. B. M. Murphy.*

INDIA—

Calcutta Statistical Association Bulletin—

August 1951—Abraham Wald: *S. N. Roy.* Study of variation in sex-ratio: *A. C. Nag.* On the efficiency of experimental designs: *H. K. Nandi.* Significance levels of the mean from a rectangular population: *D. H. Bhate.* Some two-replicate partially balanced designs: *K. R. Nair.*

UNION OF SOUTH AFRICA—

South African Journal of Economics—

September 1951—A South African national accounts research programme: *D. G. Franzsen.*

UNITED STATES—

American Academy of Political and Social Science, Annals—

September 1951—Report on China (whole number).
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American Statistical Association, Journal—

September 1951—The verification and scoring of weather forecasts: *I. I. Gringorten.* Statistics in production and inspection: *E. G. Olds.* Some statistical problems in small group research: *R. F. Bales.* Relations between prices, consumption and production: *K. A. Fox.* Actuarial science: *C. A. Spoerl.* National income: *G. Jaszi.* Statistical measurement and economic mobilization planning: *G. E. McLaughlin.* A large-sample test of the hypothesis that one of two random variables is stochastically larger than the other: *A. W. Marshall.* The distribution of the range in samples from a discrete rectangular population: *P. R. Rider.*

December 1951—Redistribution of population, 1940 to 1950: *H. S. Shryock, Jr.* Changes in income distribution in the United States: *H. P. Miller.* Results of alternative statistical treatments of sample survey data: *L. R. Klein* and *J. N. Morgan.* An economic appraisal of price measures: *R. B. Heflebower.* Mathematical models in psychological scaling: *C. H. Coombs.* Yates' correction and the statisticians: *F. Adler.* The distribution of the quotient of ranges in samples from a rectangular population: *P. R. Rider.* The measurement and prediction of attitudes: *W. G. Madow.* Erratum: On the determination of sample sizes in designing experiments: *A. M. Mood.*

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Annals of Mathematical Statistics—

September 1951—Estimating linear restrictions on regression coefficients for multivariate normal distributions: *T. W. Anderson.* On certain methods of estimating the linear structural relation: *J. Neyman* and *E. L. Scott.* Some tests based on dichotomization: *N. Blomqvist.* Sequentially determined statistically equivalent blocks: *D. A. S. Fraser.* A method of investigating the effect of non-normality and heterogeneity of variance on tests of the general linear hypothesis: *F. N. David* and *N. L. Johnson.* On the translation parameter problem for discrete variables: *D. D. Blackwell.* A stochastic approximation method: *H. Robbins* and *S. Monro.* Some bounded significance level properties of the equal-tail sign test: *J. E. Walsh.* The exact distribution of the extremal quotient: *E. J. Gumbel* and *L. H. Herbach.* The asymptotic distribution of the range of sums of independent random variables: *W. Feller.* The moment problem for unimodal distributions: *N. L. Johnson* and *C. A. Rogers.* Note on uniformly best unbiased estimates: *R. C. Davis.* Exact tests of serial correlation using non-circular statistics: *G. S. Watson* and *J. Durbin.* Distribution of the ordinal number of simultaneous events which last during a finite time: *H. von Schelling.* Minimum generalized variance for a set of linear functions: *R. G. D. Steel.* On ε-complete classes of decision functions: *J. Wolfowitz.* Almost subminimax procedures: *P. Frank* and *J. Kiefer.* On the distribution of an analogue of Student's *t*: *K. C. S. Pillai.* A property of some type A regions: *H. Chernoff.* A property of some tests of composite hypotheses: *C. M. Stein.* Note on the estimation of a bivariate distribution function: *P. B. Simpson.* On the necessary and sufficient conditions for the convergence of a sequence of moment generating function: *W. Kozakiewicz.* A note on the maximum value of kurtosis: *H. C. Picard.*

December 1951—Existence of consistent estimates of the directional parameter in a linear structural relation between two variables: *J. Neyman.* Test criteria for hypotheses of symmetry of a regression matrix: *U. Chand.* Extremal properties of extreme value distributions: *S. Moriguti.* The fitting of polynomials by the method of weighted grouping: *P. G. Guest.* A multivariate gamma-type distribution: *A. S. Krishnamoorthy* and *M. Parthasarathy.* A combinatorial central limit theorem: *W. Hoeffding.* On ratios of certain algebraic forms: *R. V. Hogg.* Normal regression theory in the presence of intra-class correlation: *M. Halperin.* Minimum variance estimation without regularity assumptions: *D. G. Chapman* and *H. Robbins.* A general concept of unbiasedness: *E. L. Lehmann.* One-sided confidence contours for probability distribution functions: *Z. W. Birnbaum* and *F. H. Tingey.* On the estimation of central intervals which contain assigned proportions of a normal univariate population: *G. E. Albert* and *R. B. Johnson.* On dependent tests of significance in the analysis of variance: *A. W. Kimball.* On a connection between confidence and tolerance intervals: *G. E. Noether.*

Bell System Technical Journal—

October 1951—Telephone traffic time averages: *J. Riordan.*

Econometrica—

October 1951—Abraham Wald, 1902–1950: *O. Morgenstern.* On some systems of equations of mathematical economics: *A. Wald* (translated by Otto Eckstein). Alternative approaches to the theory of choice in risk-taking situations: *K. J. Arrow.* Estimating patterns of savings behavior from sample survey data: *L. R. Klein.* Efficient allocation of resources: *T. C. Koopmans.* La demande des biens indirects: *R. Roy.*

Harvard Business Review—

November 1951—The Federal Reserve and the Treasury: *G. L. Bach.* Utilization of older manpower: *H. Fox.* Quality control: *T. H. Brown.* Elements of forecasting: *J. W. Redfield.* Balancing America's metal requirements: *E. Janeway.*

Industrial Quality Control—

September 1951—The tape adding machine aids statistical calculations: *V. H. Reckmeyer.* Acceptance inspection of purchased material: *J. E. Palmer* and *E. G. D. Paterson.*

Journal of Political Economy—

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Psychometrika—

September 1951—A square root method of selecting a minimum set of variables in multiple regression: *A. Summerfield* and *A. Lubin.* Effect of group heterogeneity on item parameters: *H. Gulliksen.* Estimation of other coefficients of correlation from the phi coefficient: *J. P. Guilford* and *N. C. Perry.*

Quarterly Journal of Economics—

August 1951—Relation of profit rate to industry concentration: American manufacturing, 1936–1940: *J. S. Bain.* Accelerator, theory of the firm, and the business cycle: *S. C. Tsiang.* Oil refining: yield coefficients and actual prices: *A. Manne.*

November 1951—Currency appreciation as an anti-inflationary device: *R. Hinshaw.* Reflections on the work and influence of John Maynard Keynes: *A. Smithies.*

Review of Economics and Statistics—

August 1951—The controversy over monetary policy. 1: Introductory remarks: *S. E. Harris*; 2: The place of monetary policy in the stabilization program: *L. V. Chandler*; 3: Comments on monetary policy: *M. Friedman*; 4: Monetary policy and the control of inflation: *A. H. Hansen*; 5: Fighting inflation: *A. P. Lerner*; 6: Monetary restriction and direct controls: *J. Tobin*; 7: Summary and comments: *S. E. Harris.* The ratio of income to money supply: an international survey: *E. M. Doblin.* Factors related to recent changes in income distribution in the United States: *H. P. Miller.* Monthly estimates of certain national product components, 1946–49: *C-G. Chang* and *T-C. Liu.* Living standards and productivity: *J. Burkhead.* The price system and national income and product: *H. Oshima.*

November 1951—The measurement of industrial concentration: *M. A. Adelman.* International transactions in national income accounts: *W. S. Salant.* Interregional and regional input-output analysis: a model of a space-economy: *W. Isard.*

AUSTRIA—

Statistische Vierteljahresschrift—

Vol. IV, No. 3/4—Bayessche Regel und Likelihood-Methode: *L. Schmetterer.* Gesellschaftsstatistik und Soziologie: *W. Winkler.* Produktivitätsmessung in der Baumwollspinnereiindustrie: *A. W. Klein.* Statistische Bemerkunden zu einer populationsgenetischen Frage: *J. Pfanzagl.* Über Elementanalyse psychologischer Tests: *E. Mittenecker.* Eine statistische Studie zur Frage: "Sind Leibesübungen den geistigen Leistuggen abträglich?": *W. Künzel.*

BELGIUM—

Bulletin de l'Institut de Recherches Économiques et Sociales—

August 1951—Le développement du réseau routier belge de 1830 à 1940: *G. Placq.* L'évolution séculaire du verre à vitres et de la glacerie en Belgique de 1823 à 1913: *Y. Douxchamps.* L'évolution séculaire des taux de fret et d'assurance maritimes 1819–1940: *P. Schöller.*

FRANCE—

Journal de la Société de Statistique de Paris—

April–June 1951—Sur la valeur de la preuve indiciale: *L. Amy.* La démographie comparée, base de l'histoire de la population: *J. Bourdon.* Enquêtes récentes par sondage sur l'emploi: *R. Levy-Bruhl.*

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July–September 1951—La population de l'Europe occidentale et le plan Schuman: *A. Sauvy.* Étude statistique de l'espacement des naissances: *L. Henry.* La mesure de la mortalité infantile. II. Les causes de décès: *J. Bourgeois-Pichat.* Les notions d'isolat et de population minimum: *J. Sutter* and *L. Tabah.*

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Allgemeines Statistisches Archiv—

December 1951—Das Konjunkturtest—Verfahren: *H. Langelütke.* Konjunkturtest und Statistik: *O. Anderson.* Die Erfassung der berufsfremden Tätigkeit: *F. Zopfy.* Erfolge methodischer Zusammenarbeit zwischen Arbeitsstättenzählung und Industrieberichterstattung in Bayern: *K. Pechartscheck.*

Mitteilungsblatt Für Mathematische Statistik—

Vol. 3, Part 2—Über einige nichtparametrische Testverfahren II: *E. Walter.* Zum Problem der Nichtbeantwortung bei Stichprobenerhebungen: *E. P. Billeter.* Eine allgemeine Theorie der mehrdimensionalen Korrelation: *H. C. Picard.* Der Einfluss der Messgenauigkeit auf Streuung und Spannweit bei kleinen Stichproben: *U. Graf* and *H. J. Henning.* Über die Anwendung statistischer Methoden in der Fernsprechtechnik (1 Teil): *K. Rohde.* Eine Frage zur stichprobenweisen Vorauswertung der Volkszählung 1950: *W. Swoboda.*

Weltwirtschaftliches Archiv—

Vol. 67, No. 1—Westdeutschland und die Europäische Zahlungsunion: *K. Albrecht.*
Vol. 67, No. 2—Zukunftsaufgaben der Volkswirtschaftslehre: *L. J. Zimmerman.* National Buchführung und Nationalbudget in Norwegen: *P. J. Bjerve.*

HOLLAND—

Statistica—

Vol. 5, Nos. 1–2—De centrale gedachte van de correlatierekening: *J. Tinbergen.* Gebruik van correlatierekening voor het vaststellen van werktijden in het expeditiebedrijf: *J. Sittig.* Iets over inkomenselasticiteiten, afgeleid uit huishoudrekeningen van gezinnen: *G. Stuvel.* Het gebruik van correlatierekening, om de homogeniteit van een reeks waarnemingen te controlen: *E. F. Drion.* Correlatierekening in te toegepaste psychologie: *A. D. de Groot.* Betrekkingen tussen de regressiecoëfficiënten van Galton en Frisch bij lineaire transformatie: *C. Levert.* Gesuperponeerde normale distributies en splitsing in elementaire curven: *G. W. H. N. van Alphen.*

ITALY—

Statistica—

April–June 1951—Intorno alla legittimità di molte applicazioni del metodo delle durate esatte dell'Ackland, e al metodo delle durate esatte del Gini: *V. Castellano.* Sui vari indici di cogradiazione: *T. Salvemini.* Ricerca antropologica e demografica su un gruppo di ebrei milanesi (parte seconda): *G. B. Ghidoli.*

SWITZERLAND—

Schweizerische Zeitschrift für Volkswirtschaft und Statistik—

October 1951—Die Schätzungen des sowjetrussischen Volkseinkommens: *J. Wyler.* Probleme der Bundesfinanzpolitik: *M. Iklé.*

YUGOSLAVIA—

Statistička Revija—

July 1951—On preparatory works for statistical inquiry: *M. Macura.* Population census on the territory of Croatia in 1857: *V. Serdar.* Literary statistics in Yugoslavia: *M. Babić.* Methods of calculation of future population and their application on population in pre-war Yugoslavia: *I. Lah.* Sampling mean distributions: *J. Ećimović.* Computation of the arithmetic mean, of standard deviation and of correlation coefficient by means of cumlations: *M. Blejec.* [Yugoslav text, French and English summaries.]

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INTERNATIONAL—

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December 1951—The progress of inbreeding in barley: *A. J. Bateman* and *K. Mather.*

International Journal of Opinion and Attitude Research—

Vol. 5, No. 3—The methodology of survey research: *R. L. Ackoff* and *L. Pritzker.* Germans view the U.S. reorientation program: II. Reactions to American democratization efforts: *L. P. Crespi.* The direction of perception technique of attitude measurement: *R. E. Bernberg.* The use of culture concepts in the functional analysis of public opinion: *D. N. Michael.*

Revue de l'Institut International de Statistique—

Vol. 19, No. 1—Révision critique de certains points de la méthode représentative: *L. Galvani.* Les limites de la démographie potentielle: *J. Bourgeois-Pichat.* Interview bias: *C. A. Moser.*

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I.—OFFICIAL PUBLICATIONS

(a) United Kingdom

Agricultural Research Council. Index of agricultural research in progress during 1951. London, H.M.S.O., 1951. viii, 52 pp. 9½″. 3*s.* 6*d.*

Agricultural Research Council. Soil Survey Research Board. Soil survey of Great Britain. Report No. 3. London, H.M.S.O., 1951. iv, 36 pp. 3*s.*

Central Statistical Office. Conurbation for statistical purposes. London, C.S.O., 1951. 2, 61 pp. 7 maps. 12¾″.

Commonwealth Economic Committee. Dairy produce: a summary of figures of production, trade and consumption relating to butter, cheese, preserved milk, casein, eggs, egg products, margarine ... London, H.M.S.O., 1951. xv, 115 pp. 9½″. 5*s.*

——Wool production and trade 1950–51: a supplement to Wool Intelligence ... London, H.M.S.O., 1951. 82 pp. 12½″. 5*s.*

Food, Ministry of. The urban working-class household diet 1940–1949: first report of the National Food Survey Committee. London, H.M.S.O., 1951. vi, 114 pp. 9½″. 3*s.* 6*d.*

Fuel and Power, Ministry of. Statistical digest 1950. London, H.M.S.O., 1951. 217 pp .11″. 15*s.*

Monopolies and Restrictive Practices Commission. Report on the supply of electric lamps. London, H.M.S.O., 1951. v, 199 pp. 9½″. 6*s.*

Northern Ireland. General Register Office. Census of population of Northern Ireland 1951: preliminary report. Belfast, H.M.S.O., 1951. 16 pp. 13″. 1*s.* 6*d.*

Social Survey. Consumer expenditure series. Expenditure on hairdressing, cosmetics and toilet necessities; by W. F. F. Kemsley and D. Ginsburg. London, Central Office of Information, 1951. 16 pp. 11¾″.

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Pursuant to the Act 7th and 8th Victoria, cap. 32 (1844)

(000's omitted)

1	2	3	4	5	6	7	8
		Issue Department				Collateral Columns	
Liabilities	Dates (Wednesdays)	Assets					
Notes Issued		Govt. Debt (£11,015) and Govt. Securities	Other Securities	Gold Coin and Bullion*	Silver Coin†	Notes in Hands of Public	Minimum Discount Rate
£		£	£	£	£	£	
1,375,357	Jan. 3	1,360,284	704	357	4,012	1,333,207	2% (26.10.39)
1,350,357	,, 10	1,345,230	755	357	4,015	1,314,045	
1,350,357	,, 17	1,345,308	679	357	4,013	1,297,106	
1,350,357	,, 24	1,345,260	728	357	4,011	1,284,674	
1,350,357	,, 31	1,345,236	751	357	4,013	1,282,008	
1,350,357	Feb. 7	1,345,238	751	357	4,011	1,286,378	
1,350,357	,, 14	1,345,293	695	357	4,011	1,288,152	
1,350,357	,, 21	1,345,293	692	357	4,015	1,285,819	
1,350,357	,, 28	1,345,281	706	357	4,012	1,288,981	
1,350,357	Mar. 7	1,345,230	757	357	4,012	1,295,087	
1,350,357	,, 14	1,345,786	702	357	3,512	1,300,293	
1,350,357	,, 21	1,345,737	751	357	3,512	1,312,985	
1,350,357	,, 28	1,345,727	762	357	3,511	1,320,050	
1,350,357	Apr. 4	1,345,746	742	357	3,512	1,321,707	
1,350,357	,, 11	1,345,783	706	357	3,511	1,318,343	
1,350,357	,, 18	1,345,743	744	357	3,513	1,314,896	
1,350,357	,, 25	1,345,739	748	357	3,513	1,313,848	
1,350,357	May 2	1,345,779	708	357	3,513	1,318,648	
1,350,357	,, 9	1,345,778	708	357	3,514	1,327,958	
1,350,357	,, 16	1,345,790	700	357	3,510	1,334,564	
1,350,357	,, 23	1,345,842	647	357	3,511	1,332,268	
1,350,357	,, 30	1,345,787	699	357	3,514	1,331,622	
1,350,357	June 6	1,345,787	699	357	3,514	1,337,132	
1,400,357	,, 13	1,395,786	700	357	3,514	1,340,875	
1,400,357	,, 20	1,395,774	712	357	3,514	1,343,407	
1,400,357	,, 27	1,395,766	723	357	3,511	1,349,292	
1,400,357	July 4	1,395,785	700	357	3,515	1,358,417	
1,400,357	,, 11	1,395,813	674	357	3,513	1,365,494	
1,400,357	,, 18	1,395,751	736	357	3,513	1,367,875	
1,400,357	,, 25	1,395,737	752	357	3,511	1,380,876	
1,425,357	Aug. 1	1,420,744	743	357	3,513	1,393,656	
1,425,357	,, 8	1,420,844	643	357	3,513	1,393,944	
1,425,357	,, 15	1,420,775	713	357	3,512	1,380,894	
1,400,357	,, 22	1,396,264	723	357	3,013	1,367,774	
1,400,357	,, 29	1,396,230	759	357	3,011	1,357,995	
1,400,357	Sept. 5	1,396,327	659	357	3,014	1,353,520	
1,400,357	,, 12	1,396,819	669	357	2,512	1,352,765	
1,400,357	,, 19	1,396,730	760	357	2,510	1,348,385	
1,400,357	,, 26	1,396,727	762	357	2,511	1,348,903	
1,400,357	Oct. 3	1,396,733	753	357	2,514	1,352,251	
1,400,357	,, 10	1,396,763	724	357	2,513	1,352,107	
1,400,357	,, 17	1,396,875	611	357	2,514	1,349,238	
1,400,357	,, 24	1,396,781	709	357	2,510	1,346,534	
1,400,357	,, 31	1,396,731	758	357	2,511	1,351,828	
1,400,357	Nov. 7	1,396,775	714	357	2,511	1,357,587	2½% (7.11.51)
1,400,357	,, 14	1,396,779	710	357	2,511	1,358,669	
1,400,357	,, 21	1,396,744	743	357	2,513	1,356,678	
1,400,357	,, 28	1,396,735	755	357	2,510	1,363,698	
1,400,357	Dec. 5	1,396,816	671	357	2,512	1,383,690	
1,450,356	,, 12	1,446,800	685	357	2,515	1,415,858	
1,450,357	,, 19	1,446,768	719	357	2,513	1,435,936	
1,450,357	,, 26	1,446,783	703	357	2,514	1,437,883	

* At 248*s.* 0*d.* per fine oz.

† Coin other than Gold Coin.

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WEEKLY RETURN

for Wednesday in each Week, during the year 1951

(000's omitted)

9	10	11	12	13	14	15	16	17	18
BANKING DEPARTMENT									
Liabilities				DATES (Wednesdays)	Assets				Totals of Liabilities and Assets
Capital (£14,553) and Rest	Public Deposits‡	Bankers' Deposits	Other Deposits		Govt. Securities	Discounts and Advances	Other Securities	Reserve (Notes and Coin)	
£	£	£	£		£	£	£	£	£
18,161	25,332	308,725	87,402	Jan. 3	344,046	27,443	24,643	43,488	439,620
18,195	21,016	297,400	84,843	,, 10	338,991	20,366	24,716	37,380	421,453
18,234	15,581	317,765	84,332	,, 17	339,061	18,201	24,404	54,245	435,912
18,266	15,825	306,320	83,834	,, 24	320,701	11,493	25,413	66,638	424,245
18,315	15,342	297,899	86,724	,, 31	293,581	19,725	35,616	69,358	418,280
18,367	30,827	285,313	85,802	Feb. 7	292,682	16,594	46,434	64,599	420,309
18,372	25,071	296,577	83,250	,, 14	315,356	16,394	28,742	62,778	423,271
18,424	22,247	297,755	86,087	,, 21	311,916	21,866	25,651	65,080	424,513
18,458	22,239	293,048	90,116	,, 28	313,171	16,136	32,573	61,982	423,862
18,475	13,023	290,040	84,714	Mar. 7	312,816	13,635	24,084	55,717	406,252
18,493	24,622	291,575	78,751	,, 14	319,356	19,082	24,073	50,930	413,441
18,530	25,931	302,698	86,094	,, 21					
18,536	28,445	302,378	89,280	,, 28	367,341	12,268	27,738	31,292	438,639
					361,491	8,500	25,009	38,253	433,253
18,549	28,620	302,839	89,881	Apr. 4	371,477	14,972	24,059	29,381	439,889
17,718	30,589	297,545	86,222	,, 11	362,121	13,127	24,209	32,617	432,074
17,753	20,044	319,307	81,579	,, 18	368,671	9,457	24,419	36,136	438,683
17,788	19,553	305,807	88,992	,, 25	364,641	6,403	23,765	37,331	432,140
17,823	19,240	288,243	91,178	May 2	348,656	6,645	28,914	32,269	416,484
17,861	17,858	300,050	88,350	,, 9	362,116	10,965	28,115	22,923	424,119
17,902	22,269	304,684	87,299	,, 16	378,586	12,785	24,535	16,248	432,154
17,942	22,585	306,256	82,317	,, 23	379,971	7,495	23,061	18,573	429,100
17,979	27,813	296,351	84,837	,, 30	371,776	2,792	33,189	19,223	426,980
17,997	17,321	300,041	86,280	June 6	377,536	7,475	22,854	13,774	421,639
18,052	22,872	293,831	81,414	,, 13	322,119	11,091	22,809	60,150	416,169
18,085	19,699	301,026	85,911	,, 20	336,053	7,885	23,150	57,633	424,721
18,121	24,815	290,109	86,635	,, 27	326,428	7,890	33,587	51,775	419,680
18,159	25,584	300,403	87,986	July 4	349,528	17,465	22,508	42,631	432,132
18,183	20,048	291,997	89,554	,, 11	351,198	9,581	23,534	35,469	419,782
18,231	14,545	305,750	84,132	,, 18	356,688	10,201	22,720	33,049	422,658
18,277	17,092	294,362	88,870	,, 25	367,033	7,676	23,804	20,088	418,601
18,308	16,741	294,202	91,607	Aug. 1	360,002	3,245	25,231	32,380	420,858
18,314	16,163	287,124	93,665	,, 8	348,868	4,092	30,355	31,951	415,266
18,380	18,551	295,013	90,378	,, 15	327,398	22,149	27,954	44,821	422,322
18,414	15,414	289,910	90,217	,, 22	344,523	13,654	22,550	33,228	413,955
18,453	19,392	273,582	98,926	,, 29	301,968	29,710	35,769	42,906	410,353
18,472	20,522	278,956	95,134	Sept. 5	318,613	23,015	24,344	47,112	413,084
18,492	16,507	294,618	94,583	,, 12	327,308	24,340	24,106	48,446	424,200
18,512	19,470	294,713	89,368	,, 19	326,588	18,435	24,224	52,816	422,063
18,535	17,642	289,864	91,166	,, 26	319,633	19,045	26,111	52,418	417,207
18,550	19,413	297,192	94,925	Oct. 3	336,093	21,337	23,702	48,948	430,080
17,707	18,878	300,247	94,196	,, 10	342,093	15,792	24,191	48,952	431,028
17,722	19,708	307,513	96,272	,, 17	350,218	14,557	24,498	51,942	441,215
17,778	19,504	300,015	91,916	,, 24	335,638	14,127	24,637	54,811	429,213
17,816	21,710	303,891	93,106	,, 31	332,198	20,822	33,758	49,745	436,523
17,840	16,818	300,381	95,362	Nov. 7	330,868	13,090	42,433	44,010	430,401
17,858	21,980	298,917	84,681	,, 14	335,283	17,985	27,167	43,001	423,436
17,927	14,898	310,226	85,537	,, 21	338,303	19,289	25,863	45,133	428,588
17,969	17,018	294,680	89,369	,, 28	329,493	16,808	34,531	38,204	419,036
17,986	15,161	296,193	89,016	Dec. 5	360,638	15,672	23,753	18,283	418,356
18,044	17,613	290,543	91,832	,, 12	340,598	16,836	24,430	36,168	418,032
18,080	15,000	289,608	89,489	,, 19	351,298	21,126	23,643	16,110	412,177
18,104	13,964	299,789	89,752	,, 26	369,078	18,221	20,161	14,149	421,609

‡ Including Exchequer, Savings Banks, Commissioners of Nat. Debt., and Div. Accounts and H.M. Treasury Special Account.

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REVENUE OF THE UNITED KINGDOM

Net Produce in Quarters of 1951, *and the Financial Years ended March* 31, 1950–51, 1949–50, 1948–49, 1947–48

(000's omitted)

QUARTERS ended	March 31, 1951	June 30, 1951	Sept. 30, 1951	Dec. 31, 1951	Total for Calendar Year 1951
	£	£	£	£	£
Inland Revenue—					
Income tax	856,614	214,463	230,732	204,448	1,506,257
Surtax	70,500	23,700	12,100	17,200	123,500
Death duties	48,700	51,900	43,400	44,000	188,000
Stamps	15,000	16,100	15,400	15,500	62,000
Profits tax	57,400	54,000	102,100	85,800	299,500
Excess profits tax	200	..	..		
Other Inland Revenue duties	505	55	40	15	615
Special contribution	950	920	720	530	3,120
Total Inland Revenue	1,049,869	361,138	404,492	367,493	2,182,992
Customs	236,427	242,293	245,570	265,987	990,277
Excise	192,400	184,019	193,381	191,200	761,000
Total Customs and Excise	428,827	426,312	438,951	457,187	1,751,277
Motor vehicle duties	46,954	6,414	5,529	4,178	63,075
Sale of surplus war stores	9,969	8,792	12,220	8,633	39,614
Surplus receipts from certain trading services	39,000	25,000	40,927	8,528	113,455
Post Office (net receipts)	2,062	..	1,100	..	3,162
Broadcast receiving licences	4,350	2,700	2,300	4,200	13,550
Receipts from sundry loans	7,237	2,599	16,380	1,525	27,741
Miscellaneous receipts (including Crown lands)	17,051	13,084	16,728	46,917	93,780
Total Ordinary Revenue	1,605,319	846,039	938,627	898,661	4,288,646
Self-balancing Revenue—					
Post Office	42,288	44,200	45,700	50,500	182,688
Income tax deducted from excess profits tax, post-war refunds	1,705	1,275	1,395	1,488	5,863

YEARS ended March 31	1950–51	1949–50	1950–51 (compared with 1949–50)		Corresponding Years	
			Increase	Decrease	1948–49	1947–48
Inland Revenue—						
Income tax	1,404,364	1,438,386	..	34,022	1,367,570	1,189,728
Surtax	121,100	114,700	6,400	..	97,900	91,220
Death duties	185,250	189,600	..	4,350	177,141	172,029
Stamps	54,460	51,470	2,990	..	56,433	56,280
Profits tax	258,420	260,760	..	2,340	199,090	36,120
Excess profits tax	9,350	36,200	..	26,850	79,805	252,568
Other Inland Revenue duties	595	638	..	43	700	715
Special contribution	4,850	19,600	..	14,750	79,450	..
National defence contribution	..	..	..	..	..	..
Total Inland Revenue	2,038,389	2,111,354	9,390	82,355	2,058,089	1,798,660
Customs	905,216	813,334	91,882	..	823,258	791,101
Excise	724,800	706,400	18,400	..	733,500	629,700
Total Customs and Excise	1,630,016	1,519,734	110,282	..	1,556,758	1,420,801
Motor vehicle duties	61,357	55,772	5,585	..	52,716	49,108
Sale of surplus war stores	45,355	79,138	..	33,782	99,597	197,231
Surplus receipts from sundry trading services	80,905	47,541	33,364	..	28,564	101,261
Post Office (net receipts)	962	..	962	..	..	..
Broadcast receiving licences	13,000	12,600	400	..	11,700	11,200
Receipts from sundry loans	26,876	20,244	6,632	..	17,683	23,044
Miscellaneous receipts (including Crown lands)	80,964	77,648	3,316	..	181,483	243,553
Total Ordinary Revenue	3,977,824	3,924,031	169,931	116,137	4,006,590	3,844,859
			NET INCR. £53,794			
Self-balancing Revenue—						
Post Office	171,088	162,100	8,988	..	152,700	143,300
Income tax deducted from excess profits tax, post-war refunds	8,347	11,893	..	3,546	8,751	83,183

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VOL. CXV.] [PART II

Journal of the Royal Statistical Society

SERIES A (GENERAL)

PART II, 1952.

Estimates of Expenditure on Road Transport in Great Britain

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[Read before the Royal Statistical Society, January 23rd, 1952, the President, Professor A. Bradford Hill, C.B.E., in the Chair]

Introduction

1. The amount which can reasonably be spent on a research project is partly determined by the saving to the community which may be expected to result from that project. For this and other reasons the Road Research Laboratory of the Department of Scientific and Industrial Research frequently needs to know the amount spent on various forms of road transport, in order to determine the savings to be expected from road improvements. This paper presents recent estimates of expenditure on road transport based on statistics for the year 1949, which permit more accurate estimates than have hitherto been possible. At many points in the calculation there is room for dispute, mainly on questions of what ought and ought not to be included, and on the size of some of the constituent items. The aim of this paper is, accordingly, to present the evidence, showing where different assumptions could reasonably be made, and how these would affect the result. As some of the information will not be available for 1950, values for that year have been derived from those estimated for 1949, though it is realized that this is not as reliable a method as could be desired.

2. In the calculations on road transport given below, each amount, unless otherwise stated, refers to current expenditure at market prices i.e., it includes indirect taxation and payments for the use made of capital goods during the year, but excludes any net investment in capital goods for use in future years. The totals are equal to the sum of the payments made by individuals, firms and other organizations in exchange for the provision of transport or facilities for travel by road. They are, of course, identical with the receipts of the individuals, firms, etc., providing transport and facilities for travel by road, and therefore equal to the sum of the payments they make for labour, fuel, use of capital, etc., and their profits and the sums they set aside for depreciation.

3. As most of the figures obtainable are estimates rather than exact totals, wherever possible two estimates of each figure have been obtained by independent methods. In some cases it is not possible to check the estimates of individual items of expenditure—only the horizontal and vertical totals, the horizontal total being the total expenditure on one item (e.g., tyres) for all types of road transport, and the vertical the total expenditure on all items of one type of transport (e.g., buses). For convenience, first the vertical and then the horizontal totals are discussed and each vertical total is given a reference number [I, II, etc.] and each horizontal total a letter [*a*, *b*, etc.], the same reference numbers and letters being used in the text and the tables.

Transport of Goods by Road [I–V]

4. For road hauliers the only published statistics of receipts are those given by the British Transport Commission in its accounts (3). Those relating to the vehicles of the Road Haulage Executive served only as a very general check on other figures, as during 1949 and 1950 the Executive was in the process of building its fleets by acquisition from other hauliers, so that the

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vehicles it owned at the end of each year had been under its control for varying lengths of time. Also the Executive mainly operates long-distance vehicles, which are far from being typical of all goods vehicles.

5. The receipts of the Railway Executive for the services of the vehicles it owns are suitable for inclusion in the total revenue of goods vehicles, but are little help in calculating other items in that total. This is because the Railway Executive also uses atypical vehicles, and in addition runs them at a loss in order to attract custom to the railways.

6. It was accordingly necessary to estimate the total receipts of hauliers, and the total expenditure of manufacturers and traders on running their own vehicles by estimating each item of expenditure by the vehicle operators. The data used for these estimates were (i) tables of the costs of operating goods vehicles, per mile, (ii) estimates of the miles travelled annually per vehicle, and (iii) statistics of the numbers of vehicles in use. The total is the product of the cost of operating a vehicle per mile, the number of miles it travels annually and the number of vehicles in use.

(i) Almost annually for the last 40 years H. Scott Hall (8) has compiled tables showing the cost of operating commercial vehicles. He obtains his data from a wide range of vehicle owners, and claims that, although costs vary widely, his tables are fairly representative. They are the only tables of their kind published and are widely used by vehicle owners. They give detailed estimates of each item of the fixed and variable costs of goods vehicles, and also give the total amount which the haulier should charge, including his profit. The last two editions of his tables were published in 1948 and 1950. For Table 1, figures for 1949 have been obtained by combining the two, and the author is, of course, alone responsible for any errors arising from the way in which this was done. To make Scott Hall's figures more suitable for the purpose of this paper it was found necessary to correct some of the total figures derived, but this should not be interpreted as implying any inaccuracy in his figures, which are, in any case, only offered as a guide to hauliers and were never intended to be put to the use made of them below.

(ii) The United Nations (22) have published estimates made by the Ministry of Transport of the average weekly mileages travelled by goods vehicles and their carrying capacities, grouped by the unladen weight of the vehicle and the type of carriers' licence under which it is operated. They were obtained from a sample of vehicle operators, and relate to a specimen week in May, 1948. Vehicles which were out of use for repair, or any other reason, during the week, are excluded from the figures. In calculating the annual mileage from these figures, it was assumed that it was 45 times the reported week's mileage, and that a vehicle of a given unladen weight and with a given type of carriers' licence travelled the same mileage in 1949 as in 1948.

(iii) The Ministry of Transport (15) also publishes statistics of the numbers of goods vehicles licensed by the Licensing Authorities. These are shown grouped by the unladen weight of the vehicle and the type of carriers' licence under which it is operated. The vehicles owned by the British Transport Commission and those of the petrol distributing companies were excluded from these figures for 1949. It was accordingly necessary to obtain details of the Road Haulage Executive's vehicles from the Commission's report (3), which gives the numbers in each group of carrying capacities. The total number of vehicles which the Commission reported it owned at the end of December, 1949, was appreciably greater than the number of whose acquisition the Licensing Authorities reported that they had been notified at that date. This made it necessary to adjust the figures of Road Haulage Executive vehicles in order to prevent any of them being included twice.

7. The figures thus obtained give the number of goods vehicles (other than those owned by the petroleum companies) in use at the end of December, 1949. To obtain the average number in use throughout the year, it was assumed that the number of vehicles had risen steadily during the year, and the December figures were accordingly reduced by half the year's increase in registrations.

8. Particulars of the numbers and unladen weights of the vehicles owned by the petrol distributing companies were given by the Ministry of Transport (16) in a document on "*C*" licensed vehicles released to the press, Members of Parliament "and others interested in the subject" in December, 1950. These relate to the vehicles in use in September, 1950, but as the total expenditure of these companies on running lorries was small (very roughly £5 million), the effect of any adjustment to allow for a year's increase in their numbers would be negligible.

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9. The results of these calculations are given in Table 1. The column headed "adjustments" shows the alterations which seem necessary in the light of other evidence. These adjustments are discussed below. There may be other unknown errors in all the figures. These are likely to be proportionately smaller in the totals than in the separate figures, some of which may be greatly in error. The figures for 1950 were obtained by increasing the 1949 figures to allow firstly for the higher numbers of vehicles in use, and secondly for rises in prices. They will undoubtedly need to be revised when more data become available, and so should be regarded as provisional.

TABLE 1

Expenditure on the Transport of Goods by Road; Great Britain

(£ *million*)

	1949								1950
	I		III		V	I–V *All Goods Vehicles*			
	Road Haulage Executive and "A" Licensed Vehicles	II *"B" Licensed Vehicles*	*"A" Contract and "C" Licensed Vehicles*	IV *Railway Owned Vehicles*	*Agricultural Vans and Lorries*	*Calculated Total*	*Adjustments*	*Adjusted Total*	I–V *Probable Total*
a Licences	3	2	16	–	–	21	..	21	22
b Drivers' wages and National Insurance	22	17	108	7	6	160	..	160	170
c Garages	2	1	11	–	–	14	..	14	15
d Insurance of vehicles	3	2	9	–	1	15	..	15	16
e Fuel	12	7	43	1	4	67	−2	65	95
f Lubricants	1	1	4	–	–	6	..	6	7
g Tyres	5	3	14	–	1	23	..	23	30
h Maintenance	11	7	46	3	3	70	..	70	78
i Depreciation	7	4	30	1	2	44	..	44	52
k Interest on vehicles	1	–	4	–	–	5	..	5	6
l Other expenses and profits	30	7	–	−2	–	35	+10	45	45
m Total expenses	97	51	285	10	17	460	+8	468	536

– means less than £500,000

I. "A" licensed vehicles may only be used for the carriage of goods for hire or reward.

II. "B" licensed vehicles may be used for the carriage of goods in the holder's own business and, subject to restriction, for the carriage of goods for hire or reward.

III. "A Contract" licensed vehicles may only be used under a contract made for the carriage of another person's goods. "C" licensed vehicles may only be used for the carriage of goods in the holder's own business.

V. Agricultural vans and lorries are goods vehicles registered in the name of a person engaged in agriculture, and used on roads solely for the conveyance of the produce of, and requisites for, his agricultural land.

10. *Road Haulage Executive and "A" licensed vehicles* [I].—As already mentioned, most of the vehicles owned by the Road Haulage Executive at the end of the year had been in its possession only part of the year, and had been operated with a carriers' "A" licence for the rest of the year. It has therefore been necessary to combine the two classes of vehicle.

11. *Railway owned vehicles* [IV].—These figures are obtained directly from the Report of the British Transport Commission (3), no use being made of the tables of operating costs.

12. *Agricultural vans and lorries* [V].—These are similar in function to "C" licensed lorries and, in the absence of definite information, it has been assumed that each travels the same average weekly mileage as such a lorry.

13. *Licences* [I–V*a*].—This item is the amount paid as vehicle tax and for driving licences.

14. *Drivers' wages and National Insurance* [I–V*b*].—Most of the "C" licensed vehicles weighing under $2\frac{1}{2}$ tons unladen are used for retail delivery and other local work (16) (22). The drivers of these vehicles frequently work part-time as drivers and part-time in some other capacity. It

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was therefore assumed that only half the wages of the drivers of these vehicles was part of the cost of transport, and that the other half was part of the cost of selling goods or performing other services. Agricultural vans and lorries were treated similarly. If the whole of the drivers' wages were included, the total [I–V*m*] would have been £80 million higher.

15. *Rent and rates* [I–V*c*].—This item covers only the rent and rates of garages. It was assumed that farmers do not provide any additional garage space for their vans and lorries.

16. *Insurance* [I–V*d*].—It was assumed that full comprehensive insurances were taken out.

17. *Fuel* [I–V*e*].—In 1949 goods vehicles, apart from agricultural vehicles, used 1,934,000 tons of petrol and 235,000 tons of diesel oil (11). At the prices given in the tables of operating cost, which allow for part of the fuel being bought at bulk prices, this would have cost £61 million. The estimated total expenditure on fuel for these vehicles [I*e* + II*e* + III*e* + 1V*e*] is given in Table 1 as £63 million; this seems too high. The calculated total expenditure of £67 million for all goods vehicles (including [V*e*]) is accordingly reduced by £2 million to £65 million.

18. *Tyres* [I–V*g*].—During 1949 the numbers of commercial vehicle tyres sold for replacement purposes in the United Kingdom (20) were:

	(000)
New covers	1,037
Tubes	689
Remoulded tyres	420

A commercial vehicle tyre may have cost any sum from £5 to £40, but it is assumed that they cost on the average:

New covers	£18 each
Tubes	£1 10*s*. 0*d*. each
Remoulded tyres	£8 each

After a deduction for Northern Ireland the total expenditure on commercial vehicle tyres at these prices would have been:

	£ *million*
New covers	18
Tubes	1
Remoulded tyres	3
Total	22

This total includes £3–4 million expenditure on tyres for buses, but against this may be set about £1½ million spent on tyres of sizes normally fitted on cars, which have not been included in the numbers of commercial vehicle tyres given above. In view of the arbitrary nature of the assumptions made on prices it appears reasonable to assume that the estimate of £24 million is not far from correct.

19. *Maintenance* [I–V*h*].—This item is intended to cover not only repairs and overhauls, but also minor maintenance such as washing and greasing. No attempt to adjust this figure has been made, as the horizontal check on it does not show any definite error.

20. *Depreciation* [I–V*i*].—This represents the sum which the prudent vehicle owner would put by each year to replace his vehicles, and not the income tax allowance for depreciation. In calculating depreciation it was assumed that full depreciation had been paid on all the vehicles first registered before 1940. This figure can be compared with the horizontal total [*i*] below.

21. *Interest on vehicles* [I–V*k*].—In the tables of operating costs (8) the charge for interest on the capital invested in the vehicles is based on the whole cost of the vehicle when new. Accordingly, for those vehicles for which a charge for depreciation was allowed, this item was calculated at half the rate given in the tables. It was assumed that no interest was payable on vehicles first registered before 1940 as the full amount of depreciation had been paid on them. This figure can be compared with the horizontal total [*k*] below.

22. "*Overhead*" *expenses and profits* [I and II*l*].—This item is made up of a heterogeneous collection of expenditures, including, for example, administrative expenses. It is unfortunately impossible to analyse it into its constituent parts. As obtained from the tables of operating

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costs (8) it is a residual, the difference between the total cost per week and the recommended weekly charges. If hauliers charge the amounts recommended in the tables, any errors made in the estimates of individual items of expenditure will be offset by an equal and opposite error here. The basis of the adjustment in this figure is given in the discussion of the total below.

23. *Hauliers' total receipts* [I*m* and II*m*].—If all the hauliers used the tables of operating costs (8) and if there were completely accurate information on their mileages, any estimate of the total revenue of hauliers which was based entirely on the tables would be accurate, regardless of whether the estimates of the constituent items of their costs were correct or not. If any error were made in any of the estimates of the constituent items it would be offset by an equal error in the opposite direction in the residual item—profits. This would not of course affect the accuracy of the estimates of the expenditure of those holding "C" licences, who contribute about two-thirds of the total expenditure.

24. The only available check on the accuracy of these totals is the comparison between the estimated average receipts per vehicle of the vehicles which the Road Haulage Executive acquired during the year, as calculated from the tables of operating costs, and the actual rate of receipt per vehicle of the R.H.E. during a period sufficiently short for the result to be unaffected by changes in the numbers of vehicles. During the 4 weeks ending on July 16th, 1950, a period fairly free from holidays, the number of vehicles operated by the R.H.E. (4) changed by less than 1 per cent. In this period the 38,600 motor vehicles and 1,000 horses of the R.H.E. earned £4,925,000. If each horse earned half as much as each motor vehicle, this was equal to an annual rate of receipt of £1,635 per vehicle. There was a 7½ per cent. increase in road haulage rates earlier in 1950, so that the corresponding 1949 rate of receipt was £1,521 per vehicle.

25. The average revenue per vehicle of the R.H.E. vehicles calculated, as described above, from the tables of operating costs was £1,375. If, however, the figures for total charges had been taken direct from the tables, without the adjustments in the charges for interest and depreciation mentioned above, the total revenue would have come to £1,511 per annum. It therefore seems likely that there should be a correction of £10 million to profits [items I*l* and II*l*], to offset the adjustments in depreciation and interest [items I*i*, I*k*, II*i* and II*k*]. If the total is then accurate, any errors in other constituent items can be assumed to cancel out.

Buses, Coaches, Trams and Trolleybuses [VI]

26. The returns of the Licensing Authorities for public service vehicles (14) give statistics of the receipts of bus owners; the latest available, for the year 1949–50, covers the financial years ending between April, 1949, and March, 1950, of the various vehicle operators. If the dates on which the different vehicle operators ended their financial years were chosen at random, the statistics given would relate to a period centred on the end of March, 1949. In fact there is probably a bias towards ending the financial year at the end of December or the end of March, so that the period covered by the statistics is probably centred rather later in the year than March. There is probably no great error involved in taking these statistics as applying to 1949.

27. The statistics exclude (i) the vehicles of the London Transport Executive, (ii) the vehicles of operators owning 5 or fewer vehicles, and (iii) trolleybuses and trams. The remaining vehicles (those of operators owning 6 or more buses and coaches) collected £141 million in fares.

28. Receipts per vehicle have a positive correlation with the number of buses the operator runs, and an extrapolation of the available figures suggests that, on the average, the operators of 5 or fewer buses received approximately £1,000 per vehicle in 1949. A comparison between the number of buses registered and the number included in the Licensing Authorities' returns shows that there were approximately 7,500 buses owned by the smaller operators. Their receipts in 1949 were thus very approximately £7·5 million.

29. The buses and coaches of the London Transport Executive earned £31·3 million (3) in 1949.

30. The latest available statistics of trams and trolleybuses are for the financial years ending between April, 1948, and March, 1949 (13). In that period trams outside London earned £13·12 million. As trams were decreasing in number in 1949, it is probable that in the calendar year they earned £12·5 million. Trolleybuses outside London earned £7·58 million in the period covered by the returns, but as they were declining in number it seems likely that in

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1949 they earned approximately £7·3 million. The trams and trolleybuses of the London Transport Executive earned £10·9 million in 1949 (3). The total earnings of trams and trolleybuses were thus approximately £30·7 million.

31. The receipts of public transport vehicles in 1949 are given in Table 2.

TABLE 2

Buses', Coaches', Trams' and Trolleybuses' Receipts, Great Britain, 1949

	Receipts (£ *million*)
B.T.C. (Provincial and Scottish) buses	35·8
L.T.E. buses and coaches	31·3
Municipal buses	39·1
Other operators owning 6 or more buses	66·0
Smaller operators' buses	7·5
Trams and trolleybuses	30·7
Total	210

32. Similar information for 1950 is not yet available. It appears, however, from the statistics of the British Transport Commission (4), that the receipts of the London Transport road services in 1950 were 2 per cent. below those for 1949. It also appears that, if allowance is made for the undertakings acquired during the year, the receipts of the Commission's Provincial and Scottish buses changed very little. It thus seems best to assume that expenditure on travel by buses, trolleybuses and trams was at much the same level in 1950 as in 1949.

CARS AND MOTORCYCLES [VII]

33. Some of the estimates given below of the expenditure on cars and motorcycles are partly based on estimates of the mileage these vehicles travel. Unfortunately there are no reliable estimates of their mileage already available. For the purpose of this paper it is estimated that cars and motorcycles travelled a total of 15×10^9 miles in 1949 and $18{\cdot}5 \times 10^9$ miles in 1950, but it is realized that there may be a large error in these estimates. It seems, however, unlikely that any such error will affect the final total of expenditure by more than £20 million for 1949 and £25 million for 1950, so that its effect is relatively small.

TABLE 3

Expenditure on Cars and Motorcycles, Great Britain

	1949		1950
	Expenditure (£ *million*)	*Possible Error* (£ *million*)	*Expenditure* (£ *million*)
VII*a* Licences	26	..	28
VII*c* Garages	7	..	7
VII*d* Insurance	24	± 5	29
VII*e* Fuel	46	..	77
VII*f* Lubricants	4	± 2	5
VII*g* Tyres	9	± 2	15
VII*h* Maintenance	50	±10	67
VII*i* Depreciation	78	±25	100
VII*l* Retailing of used cars	10	+20 − 5	10
Total	254	+65 −50	338

34. Table 3 gives the expenditure on cars and motorcycles in Great Britain; the following comments on the figures are given.

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35. *Expenditure on licences* [VII*a*].—The receipts from the sale of car and motorcycle licences in 1949 were £24·6 million (18). In addition, car and motorcycle drivers must have paid about two-thirds of the £1·7 million paid for driving licences, making a total of £26 million. The corresponding total for 1950 was £28 million.

36. *Expenditure on garages* [VII*c*].—This is a complicated case of a joint cost, as garages are usually used for other purposes besides the housing of the car. Also many car owners have no garage, while many householders owning garages have no cars. It is therefore very debatable how much expenditure on this item should be attributed to the use of a car. A very rough estimate can be obtained by assuming that householders with garages receive 15 per cent. of the income from ownership of dwelling houses, as assessed for schedule A income tax (7) (i.e., £67 million), and that 15 per cent. of this income (£10 million) comes from the garage. Of this, two-thirds is attributable to the car, making a total expenditure of £7 million per annum. The error in this estimate may be large proportionately, but will be small in relation to the total expenditure on cars and motorcycles.

37. *Insurance* [VII*d*].—It is assumed that car owners spent £10 (± £2) each on insurance, and that motorcyclists spent £4 10*s*. 0*d*. (± £1) each in 1949. Their total expenditure was then £24 million (± £5 million).

38. The derationing of petrol brought a rise in insurance rates for those motorists who had received only the standard ration. This did not in every case take effect in 1950, but together with the increase in registrations it probably raised the total insurance premiums paid by private motorists to £29 million.

39. *Expenditure on petrol* [VII*e*].—Private motorists used 448×10^6 gallons of petrol in 1949 (11) which, at retail prices, cost £46 million. Estimates made by J. C. Tanner (21) of the Road Research Laboratory suggest that in the summer of 1950, after the abolition of petrol rationing, car traffic had increased by 28 per cent. over its 1949 level, and motorcycle traffic by 42 per cent. As the number of cars registered had increased by 6·8 per cent., and motorcycles by 18 per cent. (17), this was equivalent to an increase of 20 per cent. in miles per car or motorcycle. It is assumed that this increase took place only after petrol derationing, that the mileage per vehicle continued at the 1949 level for a third of the year, and, from these assumptions it is estimated that they would have used 552×10^6 gallons of petrol, at an expenditure of £77 million.

40. *Expenditure on lubricants* [VII*f*].—This estimate is subject to a large margin of error, but the sum involved (£2–8 million) is in any case small.

41. *Expenditure on tyres* [VII*g*].—The numbers of car and motorcycle tyres sold (21) and the estimated expenditure on them are given in Table 4.

TABLE 4

Car and Motorcycle Owners' Expenditure on Tyres for Replacement Purposes, United Kingdom

	1949		1950	
	Number Sold (000)	*Expenditure* (£ *million*)	*Number Sold* (000)	*Expenditure* (£ *million*)
Cars:				
New covers . .	1,993	8·0	2,738	14·6
Tubes . . .	1,416	0·7	1,821	1·2
Remoulded tyres .	679	1·4	1,099	2·9
Motorcycles:				
New covers . .	284	0·5	315	0·8
Tubes . . .	287	0·1	306	0·1
Remoulded tyres .	11	..	22	..
Total . . .	..	10·7	..	19·5

It will be seen that the number of these tyres sold in 1950 was 34 per cent. greater than the number sold in 1949, compared with an increase in petrol consumption by private motorists which has been estimated above at 23 per cent. Possibly at least part of the difference may have been

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due to motorists buying tyres early to avoid price-rises—if motorists bought their tyres a month ahead of their need it would account for it almost entirely. From the total expenditure of £10·7 million in 1949 and £19·5 million in 1950 it is necessary to deduct £0·25 million and £0·4 million for tyres sold in N. Ireland, £0·4 million and £0·7 million for tyres bought for taxis and private hire cars, and £1·5 million and £3·0 million for tyres used on the smaller goods vehicles, leaving total expenditures of £9 million in 1949 and £15 million in 1950.

42. *Maintenance Expenditure* [VII*h*].—Expenditure on maintaining cars varies greatly between different cars and different owners, and any estimate even of an average figure must be subject to a large error. Estimates of expenditure per mile supplied by the motoring organizations make it possible to estimate that cars registered in 1949 received in 1949 maintenance which would have cost £51 million at 1950 prices. If the price of car maintenance rose proportionately to the wholesale price of industrial materials and manufactures (apart from textiles), this was the equivalent of an expenditure of £46 million at 1949 prices. Expenditure on maintenance in 1950 can similarly be estimated to have been £61 million. If it is assumed that motorcyclists spend $\frac{1}{3}$ as much per mile on maintenance as do car owners, their expenditure was approximately £4 million in 1949 and £6 million in 1950, making the total expenditure on maintenance of all private motorists roughly £50 million in 1949 and £67 million in 1950.

43. *The cost of depreciation* [VII*i*].—It is very debatable what should be included here, but we have tried to estimate the cost of the actual wear on the vehicle during the year. On the assumption that the vehicle has a life of 80,000 miles, and that the wear on it in a given year is valued at the prices then current, the total cost of depreciation on cars and motorcycles was about £78 million in 1949 and £95 million in 1950.

44. *Allowance for interest* [VII*k*].—It may be thought desirable to include some allowance for the interest foregone by those who prefer a car or a motorcycle to a bank balance. Reckoning interest at 2½ per cent. on half the new value of the car or motorcycle, this comes to £14 million in 1949 and £15 million in 1950. But as this is not an item of expenditure, even though the individual motorist may consider it part of the cost of running a car, it has been excluded from this calculation.

45. *The retailing of used cars* [VII*l*].—In the U.S.A., in the immediately pre-war years, two used cars were sold for every one new car (19). If the same proportion held for cars sold by dealers in Britain in 1949 and 1950, the numbers of used cars sold would have been 300,000 and 260,000 respectively. This would have been the equivalent of every car passing through the hands of a dealer once every seven or eight years. If dealers obtained £30 in 1949 and £40 in 1950 for each transaction, the total amount spent on dealing in used cars would have been approximately £10 million a year. This estimate is clearly only approximate, but it nevertheless suggests that the sum involved is probably relatively small.

46. *Total expenditure* [VII*m*].—The total expenditure on private motoring increased from approximately £250 million in 1949 to approximately £340 million in 1950. This was due to an increase of 10 per cent. in the price of motoring and an increase of 21 per cent. in its real volume. The increase in the volume of motoring is less than the 26 per cent. increase in the mileage of private motorists because the biggest increase took place in the mileage of the cheaper form of private transport, the motorcycle.

PEDAL-CYCLES [VIII]

47. Information about pedal-cyclists is very meagre, and it is not even known how many cycles are in use. The London Travel Survey (10) gives an estimate of the proportion of Londoners owning bicycles, and if London were typical the number of cycles in Great Britain would be about 8 million, but as London is probably atypical in this respect it is assumed that the number in the country as a whole is 10–15 million.

48. *Tyres* [VIII*g*].—In 1949, 4·25 million bicycle tyres and 3·78 million inner tubes were sold in the United Kingdom for replacement purposes (20), an expenditure of approximately £2 million In 1950 the corresponding figures were 4·37 million tyres and 4·12 million tubes for an expenditure of £2·5 million.

49. *Maintenance* [VIII*h*].—Preliminary tests on cycle lights carried out at the Road Research Laboratory suggest that a fairly average cyclist with battery lights spends about 5*s.* 6*d.* a year on

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batteries and bulbs, or, with a dynamo, 2*s.* 6*d.* a year on bulbs. If half the cyclists use batteries and half dynamos the total expenditure on these items would be £2–3 million a year.

50. If cyclists spend an average of 7*s.* 6*d.* a year on other items, these would claim a further £4–6 million.

51. *Depreciation* [VIII*i*].—The numbers of new bicycles made for the home market were 1·22 million in 1949 and 1·34 million in 1950 (6). As there is no information on the length of life of a bicycle it is necessary, in order to obtain figures of depreciation comparable with those given above, to assume that there is a steady investment in 1·3 million bicycles a year. If these cost £16 each in 1949 and £16 10*s.* 0*d.* in 1950, the annual consumption of bicycles would have cost £20·8 million in 1949 and £21·5 million in 1950.

52. *The total expenditure of cyclists* [VIII*m*].—For the reasons given above, it seems likely that the expenditure on cycling in 1949 was about £29–32 million, and in 1950 £30–33 million.

Taxis and Private Hire Cars [IX]

53. There were approximately 60,000 taxis and private hire cars registered in 1949. Altogether they consumed 109,000 tons of petrol (11), equal to 10·9 gallons per vehicle per week. This was probably the equivalent of about 220 miles per vehicle per week. At that mileage the minimum weekly charge given in the tables of operating costs (8) is approximately £19 in 1949 and £20 in 1950. Total charges would therefore have been approximately £57 million in 1949 and £60 million in 1950.

54. This sum is almost certainly an overstatement, as many private hire cars are run as part-time businesses. If half of them are driven part-time it would be necessary to deduct half the wages (i.e., £3 a week) from the expenditure on each of the 30,000 cars (£5 million). But much of the expenditure on taxis is in the form of tips. These probably amount to more than £5 million and so at least cancel out the other correction.

55. The above calculation may be very far from accurate, and the result is therefore rounded to £60 million for both years.

Vehicles Used in the Public Service [X]

56. In 1949, 223,000 tons of petrol were used for the public service (11). This included the fuel used by the vehicles of the armed forces, of the central and local governments, and of officials using their own cars for government business. There is no information on how much of this fuel was used in cars, how much in goods vehicles, and how much in other vehicles, such as motor-mowers for public parks. Nor is there any information on the number of vehicles in which it was used, as many of them did not appear in the statistics of registered vehicles. As the fuel used was equal to 6·1 per cent. of that used by other cars and goods vehicles it was too big an item to be ignored. Accordingly, for those items on which the government's expenditure is unknown (all but fuel and tyres), it has been reckoned as 6·1 per cent. of the relevant parts of non-government expenditure [i.e., of I–V*b*, I–V and VII*d*, I–V and VII*f*, I–V and VII*h*, I–IV and VII*i*]. The resulting total expenditure is £37 million, an estimate which cannot be very accurate.

Some Checks on the Horizontal Totals

Total Expenditure on Motor Insurance [*d*]

57. It has been estimated above that in 1949 approximately £15 million was spent on the insurance of goods vehicles, and about £24 million on the insurance of cars and motorcycles. The Road Passenger Executive spent 1¼ per cent. of its receipts on compensation and insurance for accidents, so that the total for all public transport vehicles may have been £2·6 million approximately. The insurance of taxis and private hire cars possibly cost very approximately £2½ million. The approximate total of £44 million thus obtained includes not only payments to insurance companies, but also an unknown amount of expenditure by firms who cover their accident risks themselves.

58. The only check on this total is provided by the returns made by the insurance offices to the Board of Trade (2), which cover business abroad as well as at home. These show the total

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receipts of motor insurance premiums by the British insurers to have been approximately £90 million in 1949.

TOTAL EXPENDITURE ON VEHICLE MAINTENANCE [*h*]

59. The 1935 *Census of Production* (1) recorded the gross output of repairing firms in the motor and cycle trade in the United Kingdom employing more than 10 persons as being valued at £14,906,000 in that year. To avoid duplication, the value of work given out (£256,000) and also work other than on repairing should be deducted from this, leaving a total output of £13,814,000 from these firms. The detailed figures given make it clear that, in these firms, net output per head is independent of the size of the establishment. On the assumption that this is also true of firms employing ten or fewer persons, the output of such firms was £15,724,000. Also manufacturing firms did £4,523,000 worth of repairs. Thus the total value of the repair work done in 1935 was probably about £34 millions.

60. The values of the repair work returned in the censuses of 1924, 1930 and 1935 were, at 1935 prices, per vehicle currently registered, £5·8, £6·5 and £7·1. In view of the increasing proportion of firms furnishing returns, these figures can be interpreted as showing little change in the volume of repair work per vehicle. If the volume of repair work remained unchanged, its total cost for the road vehicles registered in Great Britain in 1949 was, at 1935 prices, £50 million. If it can be assumed that the price of vehicle maintenance rose between 1935 and 1949 by the same proportion as did the wholesale prices of industrial materials and manufactures other than textiles, this was approximately £135 million at 1949 prices. This can be compared with the total output of £50 million of motor vehicle and cycle repairs "for the trade" reported by the 1948 *Census of Production*. (Repairing for the public will be covered by the Census of Distribution.)

61. It seems likely that, at the moment, many old vehicles, which are costly to maintain, are being kept in use owing to the shortage of new vehicles. This would have the effect of raising the amount spent per vehicle on repairs. On the other hand, cars and motorcycles travelled a lower average mileage in 1949 than in 1935, which would have the opposite effect.

62. The maintenance costs already given in this paper were, for goods vehicles, £70 million and for private motorists, £50 million, and therefore for vehicles used for public administration £7 million. Maintenance costs for buses and coaches were about £30 million, and for taxis, etc., £3 million, so that the combined total was about £160 million. As this includes the cost of washing, greasing and minor repairs carried out by the owners, which are not in the total of £135 million, it seems to be near the correct figure.

WAGES, DEPRECIATION, INTEREST AND PROFITS EARNED IN ROAD TRANSPORT [*b, i; k, l*]

63. The Commissioners of Inland Revenue have published estimates of the wages and salaries, profits and depreciation allowances earned in the road transport industry in 1947 (9). These figures cover classes 221–223 of the Standard Industrial Classification (5)—that is, tramway and omnibus services, taxis and private hire cars and goods transport by road, except by "C" licensed vehicles. They are:

	£ *million*
Net true income . . .	45·9
Depreciation allowances . .	23·5
Wages	183·0
	252·4

The above figures are not strictly comparable with those given in Table 1, or those obtainable from the sources used for calculating the total expenditure on public passenger transport. This is for a number of reasons:

(i) Prices rose between 1947 and 1949.
(ii) There were more vehicles in use in 1949 than in 1947.

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(iii) The income tax figures relate to financial units and may include parts of firms engaged in other industries. Similarly any haulage concern which forms less than half of a firm engaged in another industry may be excluded.

(iv) The item "Other expenses and profits" in Table 1 includes some items (e.g., clerical labour) which should be classified as wages, and other items (e.g., telephone charges) which are neither wages nor profits.

(v) Depreciation allowances are, of course, the sums allowed by the inland revenue authorities to be deducted from profits in assessing them for taxation, whereas depreciation in Table 1 means the amount the haulier should set aside to allow for the wear on his vehicle during the year. Any difference between the two if they are comparable in other ways should be offset by an equal and opposite difference in profits.

Subject to the above limitations, the comparable figures used in this paper are as given in Table 5.

TABLE 5

Wages, Profits, Interest and Depreciation

	I *and* II "*A*" *and* "*B*" *Licensed Lorries* (£ *million*)	VI *Buses, Coaches, etc.* (£ *million*)	IX *Taxis, etc.* (£ *million*)	*Total* (£ *million*)
Wages of drivers, conductors, etc.	38	90	18	215
Wages of administrative staff .	20		20	
Profits, interest, etc. . . .		29		
Depreciation	11	14	8	33
Total	69	133	46	248

From this it seems possible that the estimates of wages and profits used in this paper are a little low.

THE MEANING OF THE TOTAL EXPENDITURE ON TRANSPORT AND TRAVEL BY ROAD

TABLE 6

Gross Expenditure on Transport and Travel by Road and on the Upkeep of Roads

	(£ *million*) 1949	1950
I–V. Goods transport	470	540
VI. Travel by bus, tram, etc. . . .	210	210
IX. Travel by taxi	60	60
VII. Travel by private car or motorcycle . .	250	340
X. The use of vehicles for the public service .	40	40
VIII. Travel by pedal cycle	30	30
Total users' expenditure at market prices . .	1,060	1,220
Upkeep of roads, street lighting, etc. . .	80	90
Part of the cost of road accidents not already included	40	50
Total expenditure on roads and road transport	1,180	1,360

64. The total expenditure on transport and travel by road given in Table 6 is equal to the community's gross output of road transport. This output is "gross" in two ways:

(1) It includes some duplication; for example the expenditure of tyre manufacturing companies on road transport is included in the gross expenditure on goods transport and again in the gross expenditure on tyres.

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(2) It includes parts of the output of other industries whose products are used in the provision of transport and travel. The amounts of these depend on how the borders of industries are defined.

Three of the different ways in which the total output of transport and travel can be calculated follow from this. They are:

(*a*) Gross output at market prices (as calculated above).
(*b*) Gross output at market prices, free of duplication.
(*c*) Net output at market prices.

Each of these totals can also be calculated at factor cost by deducting taxation, and the totals thus obtained can be further varied three ways by including either depreciation only, as in the above calculations, or gross investment or both depreciation and gross investment. Many of the variations produced in this way are useful for comparison with other figures on comparable bases. If, for example, it is desired to compare the output of the road transport industry with that of other industries, the total most suitable for use is the net output (including depreciation) at factor cost.

65. For the purposes of this paper it is desirable to make two comparisons which will put into perspective the community's consumption of road transport and travel. Firstly, users' expenditure on road transport is compared with users' expenditure on all means of transport. As users' expenditure on other means of transport is calculated gross and at market prices, their expenditure on road transport needs to be calculated in the same way. This is done in Table 7.

TABLE 7

Users' Expenditure on Transport and Travel: Great Britain

(£ *million*)

	1949	1950
Road goods transport	470	540
Road passenger travel	550	640
The use of road vehicles on the public service	40	40
Total road transport and travel	1,060	1,220
Rail goods transport	200	230
Rail passenger travel	130	120
Total rail transport and travel	330	350
Other means of transport and travel	30	30
All transport and travel	1,420	1,600

66. Secondly, it is useful to compare the total output of road transport, and those parts of the output of other industries which are used in the production of road transport, with the community's total output of goods and services of all kinds. For this purpose it is most convenient to compare the gross expenditure on road transport (free of duplication) at factor cost (including gross investment) with the national income at factor cost. The adjustments this involves are shown in Table 8. It will be seen that the total expenditure on road transport was £1,080 million in 1949 and £1,190 million in 1950.

TABLE 8

Expenditure on Road Transport and Travel: Great Britain

(£ *million*)

	1949	1950
Gross expenditure on road transport and travel and roads (at market prices)	1,180	1,360
Less duplication	− 30	− 30
Plus net investment in vehicles (at market prices)	+ 60	+ 50
Less taxation	−130	−190
Gross expenditure on road transport and travel and roads (at factor cost, free of duplication)	1,080	1,190

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The national income at factor cost of the United Kingdom was £10,426 million in 1949 and £10,846 million in 1950 (7). If Northern Ireland's contribution was the same per head of population as that of the rest of the United Kingdom, the national income at factor cost of Great Britain was £10,100 million in 1949 and £10,600 million in 1950. Thus somewhere about 11 per cent. of the community's resources were devoted to road transport, both in 1949 and in 1950.

67. *Duplication.*—It is very difficult to form any accurate estimate of the amount of duplication in the gross output of road transport. The only information available to the Road Research Laboratory from which any part of it can be estimated is the number of vehicles owned by the petroleum companies in September, 1950 (16). From this it can be estimated that users' payments for fuel included very roughly £5 million spent on transporting it by road. There will be other duplications equal to the sums spent to carry road materials, new vehicles and tyres, for use in Britain, and the materials from which they are made, by road. It seems unlikely that these duplications exceeded 10 per cent. of the value of the output of these items—approximately £25 million. Accordingly the duplications are put at £30 million.

68. *Net investment in vehicles.*—This is the difference between gross investment (the total amount spent on new vehicles) and the depreciation which has been calculated above. It therefore includes any errors which have been made in the calculation of either gross investment or depreciation. As this figure is small the errors may be very large in relation to it, so no use should be made of this figure except for the adjustment for which it is used in Table 8. Any errors in the calculation of depreciation appear both in depreciation, and, in the opposite direction, in net investment, and so cancel out.

69. *Taxation.*—This item is made up of the tax on the petrol which is estimated above to have been used by vehicles, the receipts from the sale of vehicle and driving licences (13) (19), an estimate of the rates on private garages and an estimate of the purchase tax paid on new vehicles.

Conclusions

70. The estimates made above show that there are considerable gaps in our knowledge of the sums spent on road transport. Nevertheless there exist enough firm figures, or figures which can be checked, to suggest that about three-quarters of the nation's expenditure on internal transport in 1949 and 1950 was on road transport, and that in those years roads and road transport absorbed over 10 per cent. of the community's available resources.

Acknowledgments

71. The calculations given in this paper were made as part of the programme of the Road Research Board of the Department of Scientific and Industrial Research. The paper is published by permission of the Director of Road Research. The author is indebted to his colleagues at the Road Research Laboratory for assistance in the preparation of the paper.

Especial thanks are due to K. F. Glover of the Ministry of Transport for his unstinted help and advice.

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Discussion on Mr. Rudd's Paper

Mr. F. A. A. Menzler: It is my pleasant duty to propose a hearty vote of thanks to Mr. Rudd for his thorough and painstaking study of expenditure on road transport in this country. The White Papers on national income and expenditure have set a fashion in regard to quantifying the various elements that go to make up the economic environment, which cannot be too widely followed. As Lord Kelvin once said, we begin to know something about a thing only when we can measure it. I hasten to add that he was referring to matters on the material plane. Any serious essay on economic measurement like Mr. Rudd's is therefore to be warmly welcomed.

I have no intention of undertaking the exacting task of going through Mr. Rudd's estimates and exercises piecemeal, and making a lot of marginal criticisms which, in the present context, would have little practical significance in relation to the final result. When the aggregate is of the order of £1,000 millions and the unit of thought is from £10 millions to £100 millions we need not spend too much time on the satisfying pastime of statistical carping. When, moreover, we learn that the estimates have been made under official auspices, with the Ministry of Transport just round the corner, we can rest assured that by and large they will not be far wrong. I have the highest opinion of government officials, as I was one myself for over twenty years. Having said this, I am bound also to say that I find Mr. Rudd's justification for his labours, as set out in his second sentence, a little unsatisfying. One would have thought that, if this were the only reason for undertaking such exacting researches, some very rough figures readily available to all concerned would suffice to justify research on almost any aspect of roads and their use by road vehicles. Thus, the White Paper on national income and expenditure tells us that in 1949 private motoring cost us £140 millions and in 1950 £182 millions, and the White Paper for 1951—I presume that we shall get one under the new order—will doubtless show a yet higher figure for that year. Fuel and vehicle duties together amounted to nearly £100 millions in 1949, £106 millions in 1950, and £186 millions in 1951. There is, of course, an overlap between these figures and the cost of private motoring. We spend £80 millions on roads and road repairs and improvements—a large though inadequate figure. Such figures indicate the great scope that exists for research directed to ensure the more efficient and safer use of road transport.

The heavy cost to the community of traffic congestion was emphasized in the Report to the Minister of Transport prepared by the London and Home Counties Traffic Advisory Committee over a year ago. In this report the Committee stressed the need for more up-to-date factual information than is at present available about the cost of traffic delays and the nature of the benefits which can be obtained from road improvements. They remarked, in parenthesis, that they understood that the Road Research Laboratory were at present carrying out research on both matters.

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There is, thus, every promise of further papers before the Society embodying the results of these important researches.

Certainly in this country we do not devote nearly as much attention to the scientific study of road problems as the proportion of the national effort devoted to road transport would seem to warrant. In the United States the more scientific and effective use and development of roads, with special regard to safety, have been elevated to the status of a profession—that of "traffic engineering." Large research organizations with adequate financial resources are applying themselves to these problems. As is our way, we practise "traffic engineering"—as we do operational research—without knowing it, and despite the stringencies of the times our own Road Research Laboratory makes important contributions towards the solution of many traffic problems.

Mr. Rudd's estimates, of course, have wider implications which would alone justify the large amount of work they must have involved. As he points out, 11 per cent. of the community's resources are devoted to road transport, and from the figure in his Table 7 it appears that 3½ per cent. of our resources go to railway transport. In other words, transport accounts for one-seventh of our annual national effort. These figures are probably surprising to those who have previously never considered the matter. Is this proportion, apparently so high, a matter for satisfaction or for alarm? I wish I knew. It is certainly difficult to say in the absence of any generally acceptable criterion. I will confine myself, therefore, to three somewhat obvious comments.

First, it is generally found that the more developed, industrialized and prosperous is a country, so the proportion of its resources devoted to ancillary activities, such as transport, is higher. It is obviously one of the features which distinguishes a primitive rural community from a more developed economy. It is, in short, the price of civilization. The White Paper on national income and expenditure shows that the distributive trades (including a transport element) rank only after manufacturing as regards share of the national effort. In fact, transport and the distributive trades together account for, roundly, a quarter of the national effort.

Secondly, this calculation of Mr. Rudd's should stimulate our economists, and especially those who believe in a planned allocation of the national resources, to consider whether our expenditure on transport is an inevitable corollary of progress, and whether we have gone far enough or whether we have gone too far.

Thirdly, it may be that in a field which is seen to be so large, the scope for economies is also large. This is not a necessary conclusion, but it is worth while to devote considerable research to all aspects of road transport and considering carefully, for example, the economies to be derived from road construction and road improvement, using the latter term in the widest sense. It may well be that in relation to so large a current expenditure we are not undertaking enough capital investment. To those responsible for London's public road service the case for a major programme of road improvements to eliminate bottlenecks like that of Notting Hill, and generally to accelerate the movement of traffic, seems to be overwhelming. London Transport alone would save £2 millions a year if 'bus speeds increased on the average by one mile per hour. In this connection it is interesting to note what Mr. Valentine, the President of the Institute of Transport, recently said in his Presidential Address. He believes that it could be proved that the expenditure of a given sum on road improvements would produce a bigger and quicker dividend in the saving on man-hours, equipment and resources than an equal expenditure by almost any of the major industrial users of capital to-day. He goes on to mention that one well-known authority had expressed privately the conviction that such an investment on roads could be shown, if the facts were all properly established and marshalled, to yield a return in increased national productivity perhaps three times greater than the return obtained from the same capital spent on oil or steel, or even electricity, and about equal to the return from similar expenditure on coal-mining. Mr. Valentine assumes that the strength of the case has not been adequately brought home to the Government.

This leads me to the point that, to be profitable, both economic analysis and technical research must depend not only on the aggregate, but on a breakdown of the figures in various ways. To take an example, it would be of great value to know the real cost to society, in terms of expenditure on transport and its attendant accidents, of growing urbanization. I am thinking now of the enormous addition to this burden on the economy which resulted in the past from the extension of the dormitory areas of London and, to a lesser extent, of other cities. The idea is familiar enough to-day, now that town-planning is so much to the fore.

Another problem which is called to mind by Mr. Rudd's work is the proper relationship between different forms of transport, and especially rail and road transport. This raises the question of the economic basis for what the Transport Act of 1947 calls a "properly integrated system of public inland transport". But I had better keep off this bristly subject, especially at the present time.

Another thought is that our economic planners would find Mr. Rudd's estimates of greater

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assistance to them if they could be fitted into the same framework as other data. It would be helpful, for instance, if they could be related to one of the breakdowns of the National Income published in the annual White Paper. I have attempted a comparison of the two for the years in question. I must confess that I was unsuccessful in relating Mr. Rudd's figures closely to anything in the White Paper, and we should all be grateful, I think, for a reconciliation of the two approaches.

From the social point of view, such figures need to be broken down far more intimately. This was the approach adopted by the London Transport Executive in causing the London Travel Survey to be undertaken in 1949. This, of course, related only to one geographical area and to expenditure by persons on public service vehicles and local railways. There is plenty of scope here for other sample surveys. If they are properly co-ordinated the two lines of attack would supplement each other and fill in the gaps in our knowledge left by either taken alone.

To sum up, Mr. Rudd's paper provokes thought about a number of interesting and important problems. We are not yet in possession of the final analysis which will lead us to solutions, but a big step forward has been taken.

Professor J. H. Jones: But for two limiting factors I should find the greatest pleasure in seconding the motion proposed by Mr. Menzler. The first is that a gathering of expert statisticians of the ultra-modern type fills me with so much terror that I am always tongue-tied. The second is of a different character. This paper was prepared by Mr. Rudd, with the co-operation of his colleagues, as an officer of the Road Research Laboratory. Associated with the Laboratory is an advisory body called the Road Research Board which operates through a number of committees, the members of which are experts in the subjects submitted to their respective committees. One of these committees is the Economics Committee, to which the paper was first presented as a report. This committee felt that the investigation was so valuable that it should receive as wide publication as possible. The Board also held this view and decided that some means of publication should be found. I suggested that a paper to this Society would be appropriate. To that extent, therefore, I am personally responsible for the fact that Mr. Rudd has addressed the Society on this subject, and it might have been more appropriate, having regard to my vested interest in the paper, that someone else should second the motion. Within those limits, however, I feel great pleasure in doing so.

I do not propose to discuss the paper. I am more interested in the significance of the final result of the investigation. We know now that about three-quarters of total transport is road transport. We know that road transport represents over 10 per cent. of the total national activity. It has been said that in the United States road transport will double itself during the next twenty years. I do not suggest that the same rate of increase will be experienced in this country, but we must look forward to a very substantial increase during the next ten or twenty years. We have also to reckon with the fact that in the probable financial circumstances of the country it will be extremely difficult for roads to be adapted to the increased pressure of road transport for many years to come.

I believe that we are faced with an interesting economic problem as well as a most important national one. We have on the one side a railway system which once enjoyed a virtual monopoly of transport operation in this country. During the depression of the early 1930's the rail transport industry suffered very severely, partly on account of the universality of the industrial depression, and partly on account of the increasing competition of road transport. At the present time we are again suffering, or appearing to suffer, from a very heavy cost of idleness on the railways, and it is quite clear that if we could fill the railways with work within the limits of its present structure the railway industry would be benefiting from the operation of the law of increasing returns. On the other side, we have a rapidly growing road transport system which is already imposing a severe strain upon the roads of the country. It is perhaps true that, looking forward, say, five years, road transport in congested areas will be suffering from the operation of the law of diminishing returns. Thus the law of increasing returns is operating on the one side and the law of diminishing returns on the other; and I feel pretty sure that one of the major tasks in the very near future will be to decide what constitutes a square deal as between the two systems of transport.

That, I think, is the significance of the figures presented in this paper. The importance of the paper lies in the fact that at last we have, I believe for the first time, a comprehensive and conservative estimate of the statistical importance of road transport in the whole national economy. From this point we are able to move forward in a way that would have been impossible if it had not been for the valuable work that Mr. Rudd has done.

Mr. Menzler referred to traffic delays. I believe I am not betraying confidence in saying that the problem of traffic delays is also exercising the minds both of the Ministry of Transport and

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of the investigators at the Road Research Laboratory. Here again we have to face the fact that within the future that we need bother about this evening, not only is it unlikely that we shall have a change in the road system, but also unlikely that the Government will see fit to provide the necessary finances for the scale of research needed. But until we know much more about the economic effect of traffic delays we shall not be able to analyse the problem as a whole, and in particular the relationship that ought to be established between road and rail transport in this country.

For these reasons I am more interested in the final result and the significance of that result than in the details of the paper, and I personally feel most grateful to Mr. Rudd and his colleagues for their work. I hope and believe that in a few years we shall have another paper from the Road Research Laboratory carrying the knowledge of the whole problem very much farther than the point so far reached.

The vote of thanks was put to the meeting and carried unanimously

Professor GILBERT WALKER congratulated Mr. Rudd on a gallant attempt to hew the wood for a shapely structure from the jungle of official and other transport statistics. There were two points on which he wished to touch, one a point of detail in para. 5. He felt he must correct Mr. Rudd's statement that "the Railway Executive also uses atypical vehicles, and in addition runs them at a loss in order to attract custom to the railways". It was true that the collection and delivery services of the railways were run at a loss, but not primarily for the purpose of attracting custom. He had always understood that the railways did not want to have private traders' vans in their yards, and that they charged less than cost for collection and delivery of goods in order to keep those other vans out.

The second point was one on which he was prepared to learn that he was in error. In para. 70 and Table 7, Mr. Rudd had added railway gross receipts to the estimates he had prepared of the output of road transport. Railway gross receipts cover, of course, expenditure on the railway track itself for capital and maintenance. Had Mr. Rudd left out of account the actual cost of furnishing the highway, or was he assuming that the share of road transport in the use of the road itself is conveniently offset by the yield of motor taxation? That was a question which had always interested the speaker, and he thought it one to which an answer was needed if a proper transport policy was to be formulated.

It was not, however, his purpose to discuss Mr. Rudd's figures in detail, nor to ask whether his sources would always bear the weight Mr. Rudd put upon them. On that, he hoped to have guidance from the distinguished statisticians present. He wished, instead, to comment on the comprehension and organization of transport statistics generally. The mover of the vote of thanks had said that the United States spent more on roads than did Great Britain. The United States also spent more on transport statistics. The Central Statistical Office had played their part in bringing the more important series into their volumes, but consider the list of authorities Mr. Rudd had had to consult! There in the appendix to his paper one saw the diversity of sources to which Mr. Rudd had had to turn in order to obtain the information required for his paper. One could not help but catch one's breath at the guesses he had to make in order to arrive at any results—guesses which conscientious statisticians ought not to be asked to make.

Eight or nine years ago the Royal Statistical Society, reviewing official statistics, had remarked, very sagely, that all too often these had been obtained as some administrative by-product and all too frequently collated in a form unfit for scientific enquiry. Of no division of statistics in Great Britain was that criticism more just than of transport, and the criticism is as valid today as it was eight or nine years ago. Take, for example, the number of vehicles. They were collected by the tax gatherer and divided according to fiscal classification, not economic principle. Public service licences for buses and coaches were issued by Traffic Commissioners, now known as Licensing Authorities, who found they needed for the discharge of their duties information about passenger journeys, passenger receipts, and even the number of vehicles owned by each licensee; but these same authorities considering, apparently, that goods vehicles could be licensed with less ceremony, discharged the road operator, as they had power to do, from the liability imposed by the Road Traffic Act, 1933, to keep returns of journeys, loads and so on. Hence, while there was a moderate amount of information in regard to passenger traffic in public service vehicles, nothing at all was known about goods traffic moved by road. Therefore, when Mr. Rudd came to assess the volume of goods traffic passing by road he had to use a special single inquiry conducted by the Ministry of Transport, not, be it noted, for the guidance of those responsible for transport policy in Great Britain, but for the United Nations, an admirable organization, but one not quite so closely concerned with transport in Great Britain as those of us who live in this country.

The list of omissions and infertile tables as well as uncomparable statistics could be multiplied. Even the railways, with their massive returns, were not wholly immune, and it had been necessary

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to await the appearance of a report on railway electrification before it was possible to find out, even in broadest outline, which lines of railway carried the heavy traffic and paid the profits, which bore the lighter and ate away the railways' substance.

In conclusion, Professor Walker reminded the meeting that it was not certainly known what traffic was, in total, carried by road; it was not possible even to guess at the division between short and long haul, between retail delivery and inter-factory traffic on the one hand, and that traffic properly competitive with rail on the other. One did not know how many of the three-quarters of a million or so "C" licensed vehicles owned by private traders—those vehicles which have caused such heart-searchings—were employed in competition with the railways and other publicly owned carriers and how many were engaged in purely retail delivery.

Mr. Rudd had shown how much was spent on transport and had thus rendered excellent service. He had certainly, whether he was within 25 per cent. of the answer or not, given some idea of the magnitude and importance of inland transport. Professor Walker concluded by expressing the hope that the officials would now see to it that transport was furnished with a body of statistics readily available, comparable in content, and adequate to describe an industry which, it now appeared, absorbed no less than 10 per cent. of the gross national product.

Mr. G. V. HOLE thought there were two important gaps in statistical information at the present time, one in connection with retail distribution, which the Census of Distribution might well remedy, and the other in connection with transport economics, about which Professor Walker had spoken. Quite clearly Mr. Rudd's paper was a very useful contribution towards filling the latter gap.

He wondered how the statistical information given that evening compared with present-day expenditure on roads. At present much of the national production had to be devoted to re-armament, which was, of course, essential. Nevertheless, the share of the national economy devoted to road transport was probably increasing. There had been a 40 per cent. increase in national production since the last war, and much of that had been taken by road transport. Such special investigation as had been made into heavy loads and size of vehicles showed that the pressure on the roads had increased in the past and was still increasing. The number of registered commercial vehicles now on the road was 70 per cent. in excess of the pre-war number, and it was believed that extra heavy loads might well have increased by several hundred per cent. At the present time some £2,500 million per annum was devoted to gross capital formation, to use the statistical phrase. Admittedly some of the investment was on replacement in the accounting sense, but taking half that figure or £1,200 million and comparing it with the total amount spent on new or improved roads since the war, say £25 million, one could see that each year we were devoting very much less than 1 per cent. of the national capital to new roads. Before the war it had been possible to devote something over 1 per cent. of the national income to roads. Now the amount was well under 1 per cent. as Mr. Menzler had said. Before the war £3 5*s.* 3*d.* of every £1,000 of the national income had been spent on new or improved roads; now the expenditure was only 7*s.* 4*d.* All this made one realize how important it was to have more of the facts which were so necessary to guide policy.

The country was probably spending a greater percentage of its national income on road transport now than in 1930, and certainly a greater percentage than in 1920. It seemed, therefore, that a calculation such as Mr. Rudd had made should be made periodically, say once every three years. An exercise of that character would be very valuable to those who had to assist in guiding policy in regard to that very difficult and, to some extent, controversial matter.

Mr. RUDD subsequently replied in writing as follows:

Mr. Menzler suggests I relate my estimates to the framework of the national income accounts. I had already tried to do this in paragraph 66 and Table 8. Perhaps Mr. Menzler is puzzled by my selecting, from the impressive array of possible totals, the national income at factor cost as the most suitable for comparison. The reason for this choice is the dichotomy in the National Income White Papers between private and business motoring and the treatment of investment in cars and their depreciation.

Firstly, all the other possible totals in the white paper include both the gross investment in vehicles owned by business organizations and their depreciation. The gross investment in privately owned cars is included in the expenditure on private motoring—the total Mr. Menzler quotes—where, however, there is no allowance for the depreciation of the cars. This distinction between the formation of industrial capital and the purchase of durable consumer goods is, in the context of the national income as a whole, a useful one, but would prove hampering in a study of transport. There is little essential difference, for example, between the use of a person's own car for business as well as private purposes and the use of the firm's car for private purposes as well as for business,

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where the mileages travelled and the payments by the firm and the individual are the same in both cases. But the transactions would be reflected very differently in the national income accounts.

Secondly, the depreciation shown in the white papers is the amount allowed for the purpose of assessing income tax, whereas, for the study of road transport, it seemed more useful to estimate the amount of actual wear on the vehicles in the year.

The net national income at factor cost includes gross capital formation but excludes depreciation, and so is free from the defects, for the purpose of my paper, mentioned above. It is, unfortunately, no longer shown as a separate total in the National Income White Paper, but its calculation from the figures given is very simple.

Mr. Burkart has kindly drawn my attention to some estimates by Hulton Research of the number of pedal-cycles in use. They estimate that there were 11,180,000 people above the age of 16 owning cycles in the first quarter of 1949. This confirms my own estimate that the number of cycles in use by people of all ages was 10–15 million.

Professor Walker raised the problem of the track costs of road and rail transport—a difficult problem, especially as most of the necessary data, for example on the marginal cost of road use, are lacking. I tried to avoid it by merely comparing the amount actually paid, at market prices, for road transport and travel with that paid for other transport and travel, which seems to me a valid comparison, indicating the relative importance of road transport and other means of transport in the average person's expenditure. It is not a comparison of the resources devoted to each, nor should it be used as the basis of a judgment on how much taxation road users should pay, or how much money should be spent on the roads, to both of which questions it is quite irrelevant.

I am glad Professor Walker drew attention to the limitations and weaknesses of my results. These are, I hope, largely due to the inadequacies of the published statistics on road transport, which made it necessary for me to reach many of my estimates by a path that was most roundabout and difficult to find. Professor Walker, has, I think, understated rather than overstated the inadequacy of these statistics. In his own example—the goods vehicles—there used to be two sets of statistics. The first resulted from the taxing of vehicles, the second resulted from the licensing of the vehicles to carry goods, and the allocation of petrol rations to them. There has always been a marked difference between the numbers of goods vehicles recorded by the two methods at any one time, and it is not easy for the ordinary student of the subject to find an explanation of this. He would probably not discover that the second series of statistics excluded the vehicles of the petrol distributors, as this was nowhere made clear, but even if he did discover it he would still not have found the explanation of the discrepancy, which is the result of the two sets of figures being compiled as a product of different administrative functions using different definitions of a goods vehicle.

Further, the different information obtainable from the two series of statistics cannot be related. They both grouped the vehicles by unladen weights, but the first series also divided them by type of engine (petrol or diesel-oil) and the second by type of carriers' licence. We cannot tell, however, how many "A" licensed vehicles have diesel engines. Nor can we tell what kinds of vehicle they are—whether they are open lorries, enclosed vans or milk-tankers, for example. It would greatly add to the usefulness of the statistics if the vehicles with carriers' licences could be analysed according to the type of excise licence each has.

Since the nationalization of the long-distance hauliers there has been a further difficulty. The statistics obtained from licensing the vehicles now exclude those that have been nationalized, of which the British Transport Commission publishes statistics. But even if we can be sure that the vehicles of recently acquired businesses are not included by both the licensing authorities and the Commission, we still cannot add together any figures but the total numbers of vehicles, as the Commission groups its vehicles by carrying capacity instead of unladen weight. It would be very useful if the Commission could tell us the unladen weights of its vehicles, as well as their carrying capacity.

I am not certain if Professor Walker is completely right in the details of another example of the inadequacy of the statistics. I may be wrong, but I had assumed that the figures quoted by the U.N. Economic and Social Council (reference 22 of my paper) were not gathered specially for U.N. use, that the major task of collecting the figures would have taken place in any case, but that, if it were not for the needs of the United Nations, the minor task of publishing them would not have been carried out.

In some ways the availability of road transport statistics is improving. I understand that, by the time this is published, the Ministry of Transport will have published the first of a new series of statistics on buses, etc., which will remove the need for the approximations I had to make in section VI of my paper. In other ways, of which an example was given above, the situation is deteriorating.

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I should like to quote one further example from the many possible. Since the reading of my paper the Commissioners of Inland Revenue have published, for 1948, the statistics I gave in paragraph 63. They have added the valuable information that wages and salaries, profits and depreciation are equal to 57 per cent. of the turnover of the companies mainly engaged in road transport. How much more valuable this information would have been if it had related to all the operators in the industry, instead of merely 13 per cent. of them. It is nevertheless interesting to note that, if the proportionate distribution of the expenditure of the individuals, firms and local authorities who form the rest of the industry were equal to that of the companies (which is unlikely), the total turnover of the industry would have been £440 millions in 1948. The nearly comparable totals for 1949 in my paper come to £420 millions.

The main purpose of publishing my paper was to show, firstly, that there is a serious lack of many necessary statistics on road transport while there are many defects in those that are published, and secondly, that road transport is such an important part of the nation's economy that better figures are essential. I hope that these figures will soon be provided, so that better estimates than mine will be made possible.

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As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Dorothy Abrahams.
Abraham Adelstein.
Gordon Holt Byford.
John Desmond Churchill.
Frederick John David.
William Craig Edwards.
Andrew Samuel Ehrenberg.
George Dick Forwell.
John Myles Foster.
Conrad Graham.
John Harrower.
Dorothy Hunter Imison.
Gilbert Oliver James.
Patricia Jordon.
Vinayak Mahadeo Joshi.
Cecil David Kemp.
Peter Donald Lynch.
Geoffrey Lawrence Murray.
Walter Demetrius Pankhurst.
Henry Charles Parten.
Joseph Bateman Potter.
Eric Saunders.
Gurdev Singh.
John Kember Smith.
Babette Esther Stern.
Margaret Elizabeth Wigmore.

Corporate Representative

Kenneth Lionel Claude Freeborn, *representing* The British Boot, Shoe and Allied Trades' Research Association.

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The Statistics of Gambling

By A. W. Peterson

[Read before the Royal Statistical Society, February 27th, 1952, the President, Professor A. Bradford Hill, C.B.E., in the Chair]

It was with some hesitation that I accepted your Council's invitation to offer a paper to the Society on the statistics of gambling, first because my qualifications for such a task are very small, and secondly because I was doubtful whether enough is yet known about the subject to provide material for a paper which would be of any value to the Society. I felt, however, that the opportunity of arousing your interest in a field of research which has so far been sadly neglected ought not to be missed, and I therefore decided to see what I could produce, in the hope that you would make allowances not only for the inexperience of the author but for the novelty of the subject.

It is a remarkable fact that although gambling has been the subject of controversy for years and of inquiries during the present century by four Select Committees and two Royal Commissions, it was not until 1923 that any attempt was made to estimate, even in the most general way, the amount of money involved in gambling or its economic effect. The reason for this was partly the great difficulty of obtaining information, and partly the fact that the expenditure of money is not the only, or indeed the most important, measure of the social consequences of gambling, which was the main concern of these inquiries. During the 25 years before the appointment of the Royal Commission on Betting, Lotteries and Gaming in 1949 there had been a considerable increase in the amount of information available, and the Commission's estimates of the amount spent on the main forms of gambling are based on a more solid statistical foundation than any previous estimates. It is only right, however, to say that the statistical side of the Commission's Report is to some extent a by-product of their main inquiry, which was concerned with the general social implications of gambling and with possible changes in the law. It is not therefore concerned with statistical details which would have had little bearing on the Commission's inquiry. More detailed information about gambling habits is contained in a report of the Government Social Survey in the Consumer Expenditure Series entitled *Betting in Britain*, also published last year, on the results of which some of the Commission's estimates were based. Apart from these two Reports, I know of no other published study covering all forms of gambling which contains any additional statistical information.

Methods of Getting Statistical Information about Gambling

Broadly speaking there are three ways of getting statistical information about gambling: the first is to use officially published figures, which unfortunately cover only part of the field; the second is to ask those who take part in it, which is the method used in the Government Social Survey; and the third is to ask those who provide the facilities for it, which is one of the methods used, with varying degrees of success, by the Royal Commission.

Where information can be obtained from all these sources, as in the case of football pool betting and totalisator betting on horse-racing and dog-racing, a fairly detailed picture can be built up. About betting with bookmakers the sources of information are still very limited, and only a general estimate of the volume of betting is possible.

Football Pools

The figures given in the Royal Commission's Report of the number of persons who took part in football pools during the 1949–50 season are based both on evidence obtained from the football pool promoters themselves and on the results of the Social Survey, and can be checked by figures given to the Commission by the Post Office of the number of postal orders sold to the clients of football pools. The total amount staked in football pools during this season can also be calculated from three different sources—taxation receipts, the results of the Social Survey, and the figures of the total value of postal orders sold to pool clients. The Commission were able, there-

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fore, to give reliable figures of the total amount staked in football pools during the 1949–50 season (£50½m.),* and the total number of people taking part at any time during the season (about 14m.) or in any one week (about 10m.).

The section of the Commission's Report dealing with football pools is concerned mainly with the total annual stakes and the number of people taking part in this type of betting in various years. The Social Survey Report contains additional information which is of considerable interest. There is, for example, an examination of the extent to which an interest in football pools and an interest in football matches is related and of the variation in stakes according to income groups. There is for the most part no way of verifying the conclusions reached on such matters in the Social Survey Report by comparison with other sources of information, but, in view of the very large numbers of people who take part in football pools and the undoubted fact that very many of them are in the habit of staking the same amount regularly in almost every week of the season, it seems likely that this is a field in which sampling methods will produce reliable results. This is borne out by the fact that it was possible by means of the Survey to arrive at an estimate of the total amount staked during the 1949 season, which was within £1½m. of the figure indicated by taxation receipts. It was also possible to check the Social Survey conclusions about the amount of the individual stakes by comparing them with an analysis of the actual stakes on 250,000 coupons received by one of the large promoters in one week. Bearing in mind the fact that the average amount staked on each coupon is higher than the average amount staked by individuals because some coupons represent the combined efforts of a number of persons, the close correspondence between the information derived from these two sources (as shown in Table 5 of Appendix II to the Commission's Report—reproduced in the Annexe) confirms the accuracy of the Social Survey figures. These show that the average amount staked weekly by each individual was about 2*s.* 6*d.*, or on each coupon about 3*s.* 6*d.*

Totalisator Betting on Dog-racing and Horse-racing

The second form of gambling about which information is available from a number of sources is totalisator betting on dog-racing and horse-racing. Here the figures of total annual stakes present no difficulty. The Racecourse Betting Control Board is required by statute to submit annual reports of its operations to the Home Secretary, who presents them to Parliament, and these reports, which started in 1929, include figures of the total amounts staked in each year. The figure has been about £16m. in recent years. Similarly, operators of totalisators at dog-tracks are required by the Betting and Lotteries Act, 1934, to make available to the licensing authority particulars of the amounts staked on the totalisator at dog-tracks. These figures are open to public inspection, and in 1938 the Churches' Committee on Gambling started the practice of collecting this information from all licensing authorities and publishing an annual statement of the total amount staked. In recent years the publication of this annual statement has been taken over by the Home Office. In the last eight years there have been very large variations in the annual stakes on dog-track totalisators, which were about £75m. in 1944, rose to a peak of nearly £200m. in 1946, and have declined steadily since then to a figure of about £70m. in 1950.

The most probable of the reasons suggested for the post-war boom in stakes on the dog-track totalisator was the fact that there was more money at that time in the pockets of consumers than there were goods to spend it on. Suggested reasons for the decline are partly that this situation ceased to exist, and partly the imposition of a tax on this form of betting, which had the effect of making it more expensive. A reduction in turnover is the probable result of the imposition of taxation, since winnings are reduced and less money is thus available for further betting. The dog-track owners have claimed that taxation has been the direct cause of a drop in turnover disproportionate to the reduction in winnings, but this has been neither proved nor disproved.

There is less certainty about the number of people who take part in these forms of gambling and the size of the average stake. The main difficulty is that, although the total number of annual admissions can be estimated with some certainty from entertainment tax receipts and the information supplied by the proprietors of racecourses, it is not easy to say how far this total consists of a small number of attendances by a large number of people, or the reverse. The evidence

* In this paper the abbreviation "m." is used for "million".

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indicates that there is an important difference between dog-racing and horse-racing. Only 3 per cent. of the Social Survey sample had ever attended a dog-track, but of the very small number of persons concerned about one-third said that they went regularly once a week or more often. The representative of the National Greyhound Racing Society who gave evidence before the Commission put the proportion of those who attended twice a week even higher. It would be impossible without a further Survey, which would need to cover a much larger sample of those who attend dog-tracks, to reach any definite conclusions about the average frequency of attendance, but the Commission were satisfied that of the 30m. odd annual admissions to dog-tracks a very large proportion must be accounted for by a small group of regular attenders, which cannot be higher than about 500,000. Admissions to horse race-courses, on the other hand, seem to be accounted for mainly by a larger group of 2½m. people, most of whom go to a race-course less than four times a year.

An attempt is made both in the Social Survey Report and the Royal Commission's Report to estimate the size of the average totalisator stake both on the dog-track and the horse race-course. The results are not very satisfactory owing to the lack of detailed information, but they are of some value as an indication that the average amount staked on the totalisator by a single individual at one race meeting (which seems to be at present about £2 in the case of dog-racing or £4 in the case of horse-racing) is, as is to be expected, very much higher than the average stake on a football pool coupon. The figures also show that both in horse and dog-racing the size of the average stake has been decreasing during the past three or four years.

Betting with Bookmakers

The only remaining form of gambling in which a large amount of money is staked annually is betting with bookmakers, but the assessment of its volume presents great difficulties. This form of gambling is not at present subject to taxation, so that no information can be obtained from official sources, and the representatives of the bookmakers were unable to give the Commission any detailed figures. The Commission's conclusions depend, therefore, on the results of the Social Survey, and on figures which were given to them by the Board of Inland Revenue of the gross assessments of bookmakers to income tax during 1949–50, supported by certain other indications of a very general kind.

In considering the results of the Social Survey one must bear in mind that this type of betting is not so easy to investigate by sampling methods. It is not like betting on football pools, where the number of persons involved is very large and there is comparatively little variation in stakes from week to week. The number of persons who bet regularly with bookmakers is probably only between one-quarter and one-third of those who take part in football pools and the variation in individual stakes is very much larger (the Report mentions individual weekly stakes varying between £41 and 3*s*. 4*d*. in the week preceding the Survey); moreover there are considerable variations in the amounts staked at different times of the year, as, for example, during the flat-racing season and the steeple-chasing season. Finally there is a greater risk that the information given by those interviewed will be inaccurate, because it is difficult to remember the value of a number of bets made during the whole of the week, and even more difficult over a longer period, than to remember the amount staked on a single football pool coupon.

For these reasons it was not found possible in the Social Survey Report to give more than a rough estimate of the amount staked with bookmakers off the course, and no estimate is given of the amount staked on the course, either on dog-racing or horse-racing, because it was not felt that the information was sufficient to justify an estimate. The estimates of the volume of on-the-course betting contained in the Royal Commission's Report are therefore derived from other sources.

The method used in the Social Survey Report to estimate the total amount staked with bookmakers off the course in 1949 was to estimate the number of regular bettors and the amount of their average weekly stake. As regards the number of regular bettors the Survey, which was taken in March and April, 1949, indicated:

(*a*) the number of people who had bet in the week immediately preceding the Survey (10·8 per cent. of the sample);

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(*b*) the number of people who had bet since Christmas, 1948 (15·3 per cent.);
(*c*) the number of people betting on a number of specified major races. (The number betting on 8–12 of these races was 13·2 per cent.)

The main difficulty was to decide how many of those who bet in the week preceding the Survey were regular bettors, and how many regular bettors there were who did not happen to bet in that particular week. On the view that anyone who bets on eight or more of the major races is probably a regular bettor, the conclusion is reached in the Report that the number of regular bettors is between 10 per cent. and 13 per cent. of the adult population (or between $3\frac{1}{2}$ and $4\frac{1}{2}$m. people).

The average weekly stake (15*s*.) is based on the information given by those betting in the week preceding the Survey. This gives total stakes for the week in question of £$2\frac{1}{2}$–$3\frac{1}{2}$m. and, assuming that this week is typical, annual stakes of between £130m. and £180m.

It will be seen that the method used is liable to two sorts of error. The estimate of the number of regular bettors may be wrong, as may also the assumption that the weekly stakes do not vary greatly throughout the year. It does not seem likely that the number of regular bettors is much higher than the upper limit adopted in the Social Survey Report, since only 15·3 per cent. of the sample had bet at any time during the three months preceding the Survey. It is possible that the number is lower than the number of those who bet in the week preceding the Survey (10·8 per cent.), but on the whole this seems improbable, since the Survey took place at a time when there were no major races and the number of non-regular bettors was likely to be small.

It may perhaps be mentioned here that the Survey also takes account of betting by persons other than regular bettors on 12 major races. The conclusion is that these races, which include the Derby and the Grand National, account for total stakes of about £16m. The number of people betting on these two races is of course very much larger than the number of regular bettors: the percentage of the sample of betting on the Derby, for example, was 51 per cent. of men and 38 per cent. of women. It is assumed in the Survey—and it seems a reasonable assumption—that apart from the betting on these major races the amount of betting off the course by persons other than those who bet regularly is negligible.

It seems probable that the number of regular bettors lies within the limits adopted in the Report, but the next step in the argument (the amount of the average weekly stake) is less secure. There is evidence in the Report that the average weekly stake of 15*s*., calculated on the information given by those who bet in the week preceding the Survey, is considerably higher than the average weekly stake as calculated on the information given by all those who had betted during the preceding 11 weeks. For example, the average stake of 318 men who had betted since Christmas was only £4 for the whole period, as compared with an average stake of nearly £1 in a single week by 228 men who betted in the week immediately preceding the Survey. Even if the amount staked by those who did not bet in the preceding week was comparatively small, this indicates that the average amount staked weekly by regular bettors over the whole period of 11 weeks was little more than half the amount staked in the preceding week. On the other hand, it seems probable that the average amount staked weekly by regular bettors would be higher at the height of the flat-racing season, not because of any increase in the size of the average bet, but because the average number of bets per week would be likely to be greater.

Although, therefore, the Survey provides a valuable indication of the volume of this type of betting at this particular season of the year, this may not be a sufficient foundation for an estimate of the annual volume of betting. On the other hand, if the volume of betting is lower in the winter and higher in the summer, as seems likely, it is possible that the volume at the time of the Survey is fairly close to the average weekly volume throughout the year. On the whole it seems likely that the true figure of the annual volume lies somewhere between the wide limits given in the Social Survey Report, that is, between £130m. and £180m. In any event, one can feel greater confidence in this estimate than in those which were previously current, which put the volume of off-the-course betting at between £300m. and £400m.

In the Royal Commission's Report the total amount staked annually with bookmakers, both on and off the course, is estimated as being between £255m. and £280m., and an attempt is made to relate this to the annual profits of bookmakers. On the basis of the information supplied by the Board of Inland Revenue the Commission estimated the annual net profits of bookmakers as about £4m. In order to deduce from this the annual gross profits (i.e., the net profits together

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with expenses) the Commission had to rely mainly on the result of an examination of certain bookmakers' books, which was conducted at the time of the Select Committee on the Betting Duty in 1923 and which showed that the gross profits were then, on an average, four times the net profits. This would give a figure of £16m. for the annual gross profits but, in order to allow for any increase in expenses since 1923, the Commission suggested that the figure might be higher, say £20m.

If the annual gross profits are taken as £20m. and the annual stakes as £280m. the gross profits would be 7·15 per cent. of the total stakes. The Commission refer in Appendix II to a number of indications which suggest that this is not an unreasonable figure. There is, first, the comparison with the totalisator, where the rate of profit is about 10 per cent. Generally speaking there is not a great deal of difference between bookmakers' starting prices and totalisator dividends, and this suggests that the difference in the rate of gross profit cannot be very great. The term "starting price", for those who are not acquainted with it, means the average rate of odds offered by the principal bookmakers on the course on any horse just before the start of the race. It is determined by the course representatives of two sporting newspapers, and accepted by off-the-course bookmakers as the rate of odds payable on starting-price bets. The rate of odds is the multiple of the stake which the bookmaker pays to a successful bettor. Thus, if the odds about a horse are 10 to 1 against, the successful bettor, besides getting back his stake, receives a sum equal to ten times his stake. Some indication of the bookmakers' margin of profit can be obtained by comparing the starting prices of all runners with the actual results of the races. It is necessary to assume that the amount staked on each horse is the same, and subject to this assumption the difference between the number of actual winners at each rate of odds and the number of horses which should have won if the odds represented their true chances gives the bookmakers' margin of profit. Table 17 in Appendix II to the Commission's Report shows the result of such an analysis, and this indicates that the margin of profit is 10 per cent. or less where the odds are less than 9 to 1 against, but that, except where the odds are very short, the margin of profit is always over 5 per cent. The Appendix to the Report also contains some actual figures of the gross profits made by bookmakers in South Australia, where bookmakers have been required to publish this information for some years. The average rate of gross profit over a period of eight years was 9·23 per cent. in off-the-course betting and 4·55 per cent. in on-the-course betting.

The object of this section of the Commission's Report was to see whether the estimate of the total annual volume of betting with bookmakers, derived mainly from the results of the Social Survey, could be reconciled with the Commission's information about the profits of bookmakers. The Commission's conclusion was that if bookmakers' gross profits were taken as being between £16m. and £20m. annually, the relation between them and the total annual stakes (estimated as between £255m. and £280m.) was not unreasonable, since the margin of profit would be between 5·72 per cent. and 7·85 per cent.

As has been mentioned earlier, the estimates of the annual volume of betting with bookmakers current before the publication of the Commission's Report had been very much higher; for example, the figure mentioned in the evidence given by a committee representing the Churches was from £450–£500m. It was not entirely clear to the Commission how this figure had been arrived at; it seems to have been based mainly on estimates of the volume of betting in 1923 made by the Select Committee on the Betting Duty, which, for reasons discussed in paras. 29–31 of Appendix II, the Commission thought to have been too high. The method used by the Churches' Committee to arrive at estimates for the post-war years appears to have been to take the 1923 estimate of the Select Committee and then make appropriate adjustments for the change in the value of money. If this is so, the result would be to exaggerate any error in the original estimate. In any event, the Commission were satisfied that the estimate of £450–£500m. could not be reconciled with the information given to them about the annual profits of bookmakers. If this figure were correct it would follow that either the gross profits of bookmakers were higher than the Commission thought or that the margin of profit was lower, or that both these things were true. It seems most unlikely that the gross profits of bookmakers were in fact higher than the upper limit of £20m. adopted by the Commission. The gross profits of football pool promoters (which include the whole of their expenses) in the year in question were not more than about £11m., and since the number of people employed in this business is, so far as the Commission were able

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to discover, a good deal larger than the total number of people employed by bookmakers, the wage-bill must have been higher. Bookmakers, on the other hand, probably have rather heavier expenses by way of telephone lines, office accommodation, travelling, etc., so that it may be that the total expenses of bookmakers account in all for a larger annual sum than the total annual expenses of the football pool business; a figure of £20m. would, however, seem to be the outside limit. If then this figure is accepted, the margin of profit on stakes estimated at between £450–£500m. would be 4 per cent. or less, which, for the reasons indicated, seems to be very much too low.

THE ECONOMIC SIGNIFICANCE OF GAMBLING

I have dealt so far with the methods used by the Commission to assemble the raw material on which they based their assessment of the economic significance of gambling, and I shall now consider the use which they made of that material. The Commission were concerned with two different questions: first, the significance of expenditure on gambling as a part of national expenditure as a whole (dealt with in Chapter II), and secondly, with the effect of expenditure on gambling on the individual gambler (dealt with in Chapter IV, paragraphs 170–173 and elsewhere). Some critics of the Report do not appear to have realized that the Commission recognized that there is a distinction between these two forms of economic effect. The *Manchester Guardian*, in its comments on the Report, remarked:

> "The curious statistical methods of the Churches' Committee on Gambling have cast a good deal of doubt on its estimates of enormous sums—ranging from £1,000 millions in 1946 to £650 millions last year—spent on gambling. But the Commission's own estimate of a mere £70 millions a year in 'personal expenditure' on gambling seems to write down almost as much as the Churches' Committee writes up. The Commission argues that since gamblers sometimes win, the national total of winnings must be offset against the national total of stakes, and that only the difference can be reckoned as 'personal expenditure'. If the 'average gambler' existed this argument might be acceptable. But the 'average gambler' is a statistical fiction, and the fact that one man who has staked his wages makes a profit does not in the least offset the 'personal expenditure' of half a dozen others who have staked their wages and lost".

I hope to show that the Commission were not unaware of this important truth.

In Chapter II the Commission were concerned with expenditure on gambling in relation to other forms of personal expenditure by consumers, and they took the view that in this sense personal expenditure on gambling must be regarded as equivalent to the total amounts staked less the amounts returned in the form of winnings or, in other words, the gross profits of those who provide facilities for gambling together with the amount which is taken in the form of special taxation either on stakes or on the conduct of gambling facilities. As has already been explained, the Commission estimated the gross profits of bookmakers at about £20m., to which it was necessary to add £2·5m. paid by bookmakers in the form of special taxation on betting at greyhound-tracks. As regards the other main forms of gambling the Commission were able to give figures, which are accurate within narrow limits, of the actual amounts retained by the promoters of the various forms of gambling and the amounts taken in taxation. To these figures the Commission added a comparatively small sum to cover expenditure on other forms of gambling, such as the Irish Hospitals' Trust Sweepstakes, private lotteries, raffles, etc. The estimate of expenditure on these minor forms of gambling is a very rough one, but in all probability it is too high rather than too low. According to the Social Survey Report the total stakes on forms of gambling other than horse-racing, dog-racing and football pools were about £20m. in 1949, and, if this is so, it is improbable that the amount retained by the promoters was as high as £5m., which was the figure taken by the Commission.

The Commission's conclusions were set out in the following table, which is taken from the Report:

The Commission concluded from these figures that personal expenditure on gambling was about ·8 per cent. of total personal expenditure, and pointed to the fact that it was very much lower than personal expenditure on such items as alcohol or tobacco.

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Variations in Personal Expenditure on Gambling

	Personal Expenditure on Gambling (£ million)						
	1938	1941	1946	1947	1948	1949	1950
Horse race-course totalisators . .	1	·3	1·7	2·1	2·6	2·6	2·6
Dog-track totalisators . . .	2·4	2·2	12	7·9	15·4	13·7	11·2
Football pools	4·8	·8	5·8	10·1	22·5	26·4	26
Bookmakers (off and on the course) .	10	3	25	22	22	22·5	22·5
Other forms of gambling . . .	2·5	1	3	4	5	5	5
Total	20·7	7·3	47·5	46·1	67·5*	70·2†	67·3†

* Of which about £20 million represents taxation.
† Of which about £26 million represents taxation.

The Commission also considered the demand made by gambling on national resources, and concluded that in recent years gambling has absorbed about ½ per cent. of the total annual flow of national resources. The figure is of course lower because the taxation element is excluded. The national cost of providing facilities for gambling still appears to be considerably less than the cost of providing alcoholic beverages or tobacco, though the difference in the case of tobacco is less marked on account of the very high tax element in the retail cost of tobacco.

When the Commission came to consider the effect of gambling on the standard of living of individual gamblers, they accepted the view that some allowance ought to be made for the way in which winnings were redistributed in certain types of gambling. They did not, however, take the view which appears to underlie criticism of the type contained in the *Manchester Guardian*, that the general effect of all types of gambling is to transfer the stakes of the majority of unsuccessful gamblers to a minority of successful ones.

To produce this effect it is necessary either that a large part of the stakes of all gamblers are redistributed in the form of prizes which are very large in relation to the amount staked, or that a minority of gamblers is consistently much more successful than the rest. In football pools the odds against a successful forecast in the most popular types of pool are so large that amounts may be won which are equivalent to as much as 10 million times the amount staked, and it is obvious that for every gambler who wins such a prize there must be a very large number who lose their stakes. Although there are also smaller prizes, the general level of prizes in relation to stakes is high and it is inevitable that most gamblers should get back very little of their stakes.

In the two other main forms of gambling, however—dog-racing and horse-racing—the amounts which may be won are comparatively small in relation to the amount staked. Table 17 in Appendix II of the Royal Commission's Report (reproduced in the Annexe) shows that out of 12,329 horses the number of winners at odds of between 10 : 1 and 20 : 1 was only 124, and at odds higher than 20 : 1 only 49. In dog-racing odds of more than 5 : 1 are rare. The individual gambler can of course increase the odds by backing combinations of horses or dogs, and this is commonly done in dog-racing by means of the forecast totalisator and in horse-racing by such bets as doubles and accumulators; but generally speaking, the average level of odds is comparatively low.

It seems clear that in these circumstances the relation between the amount received by each gambler in the form of winnings and his total stakes will, over a sufficiently long period of time, approximate to the relation between the stakes and winnings of gamblers as a whole. For reasons already given, the Commission estimated that about 90 per cent. of the stakes in these forms of gambling were returned in the form of winnings. If allowance is made for a variation in each individual case of about 20 per cent. on either side of this figure, it seems probable that this would cover the great majority of regular gamblers, so that the maximum cost to the individual would be 30 per cent. of his total stakes.

Evidence to support this view can be obtained from the analysis, published in *Sporting Life*, of the results of the tips given by the racing correspondents of a number of newspapers. This analysis shows the number of winning and losing nap selections (which is, I understand, the trade term for what the correspondent regards as his best tip for the day), and the amount of gain and loss over a period on the assumption that £1 is staked on each selection. During the 1951 flat-

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racing season the number of selections given by each of the 23 correspondents listed was about 188. One correspondent showed a profit of about 22 per cent. of his total stakes; three others showed profits of about 16, 7 and 3 per cent.; seven showed losses varying between about 1 and 10 per cent.; and the remaining twelve showed losses varying between 11 and 23 per cent. The average rate of loss on all the correspondents' selections was 7·6 per cent.

Another indication of the different way in which winnings are redistributed in betting of the football-pool type and in other forms of betting may be found in the answers quoted in the *Social Survey Report* to a question about the amount which informants had won or lost by betting. Of those who betted on football pools 7 per cent. regarded themselves as having gained since the start of the season, 16 per cent. as breaking even and 76 per cent. as having lost. For those betting on horses the percentages were 29, 24 and 42 per cent. respectively. Although, as the Report remarks, this suggests a certain amount of optimism on the part of those who bet on horses, it is not wholly inconsistent with the views advanced above about the way in which winnings are redistributed in this type of betting. If those informants who said that they broke even may be assumed to include all those who lost not more than 5 per cent. of their total stakes, the results resemble closely the results of the predictions by newspaper correspondents.

The figure of £150m., which the Commission took as representing approximately the amount which gambling costs to those who take part in it, includes a considerable allowance for the fact that many gamblers lose more than the average amount lost by all gamblers. In the case of football pools the Commission ignored entirely all winnings and regarded the whole of the £50m. staked as money lost: in the case of betting on dog-racing and horse-racing the Commission assumed that of the £375m. staked, £100m., or nearly 30 per cent. represented money lost. The Commission felt that this was an adequate allowance to make for the tendency which undoubtedly exists in all forms of gambling to a greater or less degree to enrich some gamblers at the expense of others. If the figure of £150m. is accepted, the burden which gambling imposes on the standard of living of the average gambler does not appear to be very large. The number of those who take part in the main forms of gambling is at least 15m., so that the average maximum loss would be in the region of £10 annually. There is also a good deal of evidence in the *Social Survey Report*, particularly in regard to betting on football pools, that the amount spent on gambling increases proportionately to the income of the gambler, which suggests that, so far as the less wealthy members of the community are concerned, an expenditure of £10 annually would be on the high side.

The Element of Skill in Football Pool Forecasting

There is one section of the Commission's Report which is unconnected with their investigations of the economic and social effects of gambling, but which may be of rather special interest to statisticians. I refer to the analysis in Appendix III of evidence given to the Commission by Mr. Hubert Phillips on the element of skill in the forecasting of football pools, which should be read together with Mr. Phillips' evidence, which has also been published.

Mr. Phillips' evidence was designed to show, by mathematical reasoning, that the element of skill on the part of competitors has no effect on the results of football pools. It would be impossible to summarize, within a reasonable space, all the arguments which he put forward, and I shall confine myself to the analysis which he gave of the results of two of the most popular types of pool, the Penny Points Pool and the Treble Chance Pool.

In the particular Penny Points Pool which Mr. Phillips examined, the competitor has to forecast the result of 14 matches in a list given by the promoter. For each draw which he forecasts correctly he receives 3 points, for each away win 2 points and for each home win 1 point. The amount of the pool available for distribution to winners after the promoter has deducted his commission and expenses and taxation has also been deducted is divided as follows:

First dividend (competitors scoring the greatest number of points) . .	45 per cent.
Second dividend (competitors scoring one point less than the greatest number	20 ,,
Third dividend (competitors scoring two points less)	14 ,,
Fourth dividend (competitors scoring three points less)	12 ,,
Fifth dividend (competitors scoring four points less)	9 ,,

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Mr. Phillips pointed out that it is possible, in some circumstances, to deduce the number of winners of each dividend from the figures published weekly of the amount of the various dividends. The relative number of winners can be calculated precisely from the knowledge of the proportions in which the pool is divided and, since the number of winners must in all cases be a whole number, it is frequently possible to calculate the smallest number of first dividends which can conceivably have been paid. For example, the ratio between the number of winners of the first dividend and the number of winners of the second dividend was on one particular date 14·2843; the smallest whole numbers consistent with this ratio are 7 first dividends and 100 second dividends; hence the number of winners of the first dividend must be 7 or a multiple of 7. The amount of the first dividend on this occasion was £4,624; if there were 7 first dividends the total amount of stakes in this particular pool would be about £140,000, which is a figure consistent with the other information available about the amount of the total stakes in the pools organized by this promoter.

It is also possible to calculate from the results of the matches in the list what the number of winners of each dividend would be, on the assumption that the total number of forecasts submitted consisted of an equal number of every possible combination of results. As Mr. Phillips pointed out, this would not in fact happen even if all forecasts were made at random, owing to the fact that the total number of forecasts submitted is about 35m. and the number of possible different forecasts is itself over 4½m. In the case of first dividends, for example, since only one forecast out of 4,782,969 possible forecasts is correct there would be wide variations from week to week in the number of correct forecasts, even if all forecasts were made at random. The deviation from the norm would be progressively smaller in the case of second, third, fourth and fifth dividends, owing to the much larger number of possible forecasts qualifying for each of these dividends.

The formula for calculating the number of theoretical winners of each dividend is given in paragraph 27 of Appendix III to the Commission's Report. The theoretical number of winners of the first dividend is obtained by dividing the total stakes in the pool by £20,000, which is roughly equivalent to the amount staked on 4,782,969 forecasts at 1*d.* per forecast. The theoretical number of winners of the other dividends is obtained by multiplying the number of winners of the first dividend by the following factors:

Second dividend . . $2a$.

Third dividend . . $2a(a-1)+2b$.

Fourth dividend . . $\frac{4a(a-1)\ (a-2)}{3}+4ab+2c$.

Fifth dividend . . $\frac{2a(a-1)\ (a-2)\ (a-3)}{3}+2b(b-1)+4ac+4ab(a-1)$,

where a, b and c are the number of home wins, away wins and draws respectively included in the results of the matches.

The principle on which this formula is based is that there is a fixed number of different forecasts scoring one, two, three and four points less than the maximum, the number being decided by the actual results of the matches included in the list.

Table 20 in the Report (part of which is reproduced in the Annexe) contains a comparison between the theoretical and actual number of winners of dividends in one pool of this type for the whole of the 1949–50 season. It is arranged according to the results of the matches so as to show how in theory, and also in practice, the number of winners of dividends increases with the number of home wins (and, to a less marked degree, the number of away wins) included in the list of matches.

I am not myself competent to say much about the contents of this table. To a layman the correspondence between the figures of actual and theoretical winners of dividends is very striking, and it hardly seems possible to account for it in any other way than that suggested by Mr. Phillips. The Commission were able to obtain expert advice on the matter, in the light of which they said that "Mr. Phillips' evidence demonstrates that the most important single factor determining the number of winners of dividends in this pool during this period is the number of home wins, away wins and draws in the list of matches included in each coupon". They also suggested that the

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figures indicated that this was not the only determining influence, because there is a distinct tendency for the figures of the theoretical and actual number of winners in each week to show a variation in the same direction and often in approximately the same degree. They suggested that the likely explanation for this tendency was that there was a general consensus of opinion among competitors about the probable results of certain matches in each week's list, and that where this opinion turned out to be correct the effect would be that the number of actual winners of all dividends would be higher than the theoretical norm. Similarly, where it was wrong the effect would be the opposite. This view was borne out to some extent by information submitted by two football pool firms about the extent to which there is agreement among competitors' forecasts of the results of particular matches.

Mr. Phillips also submitted evidence on the Treble Chance Pool, in which the competitors' object is to select eight matches resulting in a draw from a list of matches, usually about 50 in number. If the number of matches in the list which result in a draw is only eight or nine the odds against any competitor doing this successfully are enormous. Mr. Phillips sought to show that the number of competitors making successful forecasts was determined, not by the use of skill, but by the fact that as the number of drawn matches in the list increases, the number of possible different forecasts containing eight draws increases very rapidly and therefore the chances against any competitor forecasting eight draws is correspondingly reduced. For example, from a list of 50 matches it is possible to select over 750 million different groups of eight matches; if only eight matches in the list are drawn, only one of these selections can be correct, but if 15 matches are drawn there are 3,003 different selections, each containing eight draws, and with 16 drawn matches 6,435.

Mr. Phillips' evidence, which was concerned only with first dividends, shows clearly that there is an important connection between the number of drawn matches and the size of the dividend. The Commission did not feel, however, that it was possible to infer that this is the only determining factor. In order to test Mr. Phillips' argument they applied the same principles (by means of the formulae given in Table 22—reproduced in the Annexe) to the examination of second, third and fourth dividends, but they did not find that the results were conclusive. The difficulty of applying Mr. Phillips' methods to this type of pool is, as the Commission said, that the total number of forecasts submitted in any one week is only a small fraction (not more than about one-fiftieth) of the number of possible different forecasts. Nevertheless the Commission's further inquiries did not in any way cast doubt on Mr. Phillips' arguments. The following are two examples of the application of the formulae given in Table 22 to the results of particular pools:

On December 10th, 1949, the number of matches included in Littlewood's Treble Chance Pool was 51; there were 29 home wins, 10 away wins and 12 draws. The theoretical dividends and the dividends declared were:

	Theoretical Dividends			*Actual Dividends*		
	£	*s.*	*d.*	£	*s.*	*d.*
First dividend . . .	16,080	0	0	55,224	0	0
Second dividend . . .	502	10	0	587	9	10
Third dividend . . .	21	15	0	44	6	0
Fourth dividend . . .	4	4	0	4	10	0

On April 1st, 1950, the number of matches in the list was 48; there were 18 home wins, 14 away wins and 16 draws. The theoretical and actual dividends were:

	Theoretical Dividends			*Actual Dividends*		
	£	*s.*	*d.*	£	*s.*	*d.*
First dividend . . .	366	10	0	454	16	4
Second dividend . . .	14	14	0	13	5	0
Third dividend . . .		15	0	1	0	0
Fourth dividend . . .		3	0		4	0

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These two cases have been selected as examples of two extreme types of result, one where the dividends generally are high and the other where they are low. In neither case is there a close correspondence between all the theoretical and actual dividends, but the general pattern of the theoretical dividends does correspond with that of the actual dividends.

These brief observations on Mr. Phillips' evidence will perhaps be sufficient to show what a wealth of material there is here for students of the theory of probability. May I end by expressing the hope that in this field, as in the field of gambling statistics generally, the paper which I have had the honour to submit to the Society may at least serve to stimulate more expert discussion and research.

ANNEXE

Statistical tables from the *Report of the Royal Commission on Betting, Lotteries and Gaming*, 1949–51, referred to in the paper.

TABLE 5

Football Pools: Amounts Staked on Coupons and by Individual Participants

Analysis submitted by Sherman's Pools Ltd.		*Social Survey*	
Amount Staked on Coupon	*Percentage of Coupons Examined*	*Amount of Individual Stake*	*Percentage of Sample Taking Part in Pools*
1*s.* and less	9·8	1*s.* and less	25·0
Over 1*s.*, up to 2*s.* 6*d.* inclusive	42·5	Over 1*s.*, up to 2*s.* 6*d.* inclusive	46·6
Over 2*s.* 6*d.*, under 4*s.*	20·6	Over 2*s.* 6*d.*, under 4*s.*	11·8
Over 4*s.*, under 6*s.*	20·1	Over 4*s.*, under 6*s.*	11·3
6*s.* and over	7·0	6*s.* and over	5·3
Over 10*s.* to 20*s.* inclusive	2·72		
Over 20*s.*	2·11		

TABLE 17

Analysis of Results of Certain Horse-races

Odds	*Runners*	*Actual Winners*	*Expected Winners*	*Bookmakers' Profit (Per Cent)*
At odds-on	272	160·5	173	7
Evens to 13–8 against	385	164	167	2
7–4 to 9–2	1,755	424·5	445	5
5–1 to 9–1	1,981	240·5	267	10
10–1 to 100–6	2,814	124·5	209	40
20–1 and above	5,122	49	204	76
Total	12,329	1,163	1,465	20

(·5 in the actual winner column represents a dead heat.)

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TABLE 20

Analysis of Theoretical and Actual Winners in Littlewood's Penny Points Pool (1949–50)

Date	Results H.	A.	D.	Theoretical Winners	Estimated Actual Winners	Discrepancy +	Discrepancy −	Ratio
26.xi.49	1	5	8	7·5	3		2·5	
				15	42	2·8		
				76	104	1·3		
				272	364	1·3		
				544	675	1·2		
18.iii.50	1	8	5	6·8	11	1·6		
				14	33	2·3		
				109	109	1·0		
				286	362	1·2		
				899	924	1·0		
10.ix.49	2	8	4	6·5	11	1·6		
				26	28	1·0		
				129	352	2·7		
				465	455		1·0	
				1,344	1,562	1·1		
8.x.49	3	5	6	7·3	8	1·0		
				44	36		1·2	
				161	145		1·1	
				585	436		1·3	
				1,696	1,400		1·2	
8.iv.50	4	6	4	6·2	12	1·9		
				49	66	1·3		
				222	323	1·4		
				838	1,095	1·3		
				2,636	3,168	1·2		
19.xi.49	4	6	4	7·5	10	1·3		
				60	52		1·1	
				269	317	1·1		
				1,015	1,382	1·3		
				3,193	4,330	1·3		
6.v.50	8	2	4	5	23	4·6		
				79	237	3·0		
				575	1,265	2·2		
				2,579	6,578	2·5		
				8,432	9,338	1·1		
21.i.50	8	3	3	7·7	8	1·0		
				123	151	1·2		
				909	1,233	1·3		
				4,235	5,284	1·2		
				14,630	13,872		1·0	
27.viii.49	8	5	1	6·9	9	1·3		
				110	134	1·2		
				836	907	1·0		
				4,178	4,111		1·0	
				15,837	15,426		1·0	
24.ix.49	9	4	1	6·8	19	2·7		
				123	191	1·5		
				1,041	1,245	1·1		
				5,603	6,087	1·0		
				22,111	20,549		1·0	
1.iv.50	1	6	6*	20·2	20		1·0	
				41	65	1·5		
				243	222		1·0	
				729	807	1·1		
				1,701	1,740	1·0		
11.ii.50	7	1	5*	22·1	7		3·1	
				309	135		2·2	
				1,899	883		2·1	
				7,021	3,366		2·0	
				19,165	11,046		1·7	

* One match cancelled.

(*Note.*—A part only of this table is reproduced; it includes the results for the first six dates in the full table and those for the last six.)

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TABLE 22

Method of Calculating the Number of Theoretical Winning Lines and the Theoretical Dividends in an 8-Match Treble Chance Pool, where the First Dividend is paid on 24 Points.

1 *No. of Points Scored*	2 *Correct Forecasts Required*	3 *Number of Different Lines Scoring this Number of Points*	4 *Amount of Theoretical First Dividend (in £s to a Stake of* 1s.*)*
24	8 draws	${}^{c}C_{8}$	$\frac{10}{800} \times \frac{{}^{n}C_{8}}{{}^{c}C_{8}}$
23	7 draws and 1 away	${}^{c}C_{7} \times b$	$\frac{5}{800} \times \frac{{}^{n}C_{8}}{({}^{c}C_{7} \times b)}$
22	7 draws and 1 home or 6 draws and 2 aways	$({}^{c}C_{7} \times a) + ({}^{c}C_{6} \times b\,(b-1))$	$\frac{3}{800} \times \frac{{}^{n}C_{8}}{({}^{c}C_{7} \times a) + ({}^{c}C_{6} \times b\,(b-1))}$

Notes:

(1) In the above formulae—

n = number of matches in list.
a = number of home wins in results of matches.
b = number of away wins in results of matches.
c = number of draws in results of matches.

The symbol ${}^{n}C_{8}$ represents the number of different combinations of 8 matches selected from a list containing n matches (i.e., $\frac{(8+1)\,(8+2)\,(8+3)\,\ldots\ldots\,n)}{1 \times 2 \times 3 \times \ldots\ldots\,(n-8)}$.

The symbols ${}^{c}C_{8}$, etc., represent the number of different combinations of 8 drawn matches selected from a list containing c drawn matches.

(2) The method used in col. 4 to calculate the theoretical dividend is as follows:

(*a*) It is assumed that every line submitted is different and that the amount staked on each line is 6*d*. The number of lines submitted (L) is therefore 40 times the total stakes (S) (in £s), i.e., $L = 40 \times S$.

(*b*) The number of lines scoring 24 points which will, in theory, be submitted if the total number of lines submitted is L is $\frac{{}^{c}C_{8} \times L}{{}^{n}C_{8}} = \frac{{}^{c}C_{8} \times (40 \times S)}{{}^{n}C_{8}}$.

(*c*) It is also assumed that 50 per cent. of the total stakes are deducted for commission and expenses. The amount available for distribution to persons submitting a line containing 24 points will, therefore, be $\frac{1}{4}$ of the total stakes, i.e., S (in £s.).

(*d*) The amount of the theoretical dividend in respect of lines scoring 24 points is therefore

$$\frac{S}{4} \div \frac{{}^{c}C_{8} \times (40 \times S)}{{}^{n}C_{8}}$$

in £s to a stake of 6*d*.
When the two factors are multiplied together S disappears, and the theoretical dividend, in £s to a stake of 1*s*., is $\frac{{}^{n}C_{8}}{80 \times {}^{c}C_{8}}$.

(*e*) The theoretical dividends in respect of lines scoring 23 points and less can be worked out in the same way. They are expressed in Col. 4 in a form which shows how the theoretical dividend is affected by the fact that a smaller proportion of the total amount available for distribution to winners is divided among winners of the second and third dividends. It may be observed that if no line scoring 24 points is submitted and the first dividend is paid on lines scoring 23 points, the theoretical dividend would be

$$\frac{10}{800} \times \frac{{}^{n}C_{8}}{({}^{c}C_{7} \times b)},$$

and so on.

(3) The formulae in the table are given as examples of the method used. Similar formulae can be worked out showing the theoretical number of lines scoring 21 points and less.

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Discussion on Mr. Peterson's Paper.

Mr. Hubert Phillips: I much appreciate the invitation to move this vote of thanks to Mr. Peterson, not only because of my interest in this subject, but also because I saw something of the admirable work done by Mr. Peterson as secretary to the Royal Commission. In this capacity he acquired what is probably an unrivalled knowledge of gambling, as organized in this country, and of such statistical material as exists. I doubt if any information of significance is available upon which Mr. Peterson has not touched in the course of his survey.

This does not mean that the data, as we have them, are anything like complete. It is difficult to get accurate social statistics where the techniques of government and administration supply no sort of official yardstick. Thus, we know exactly how much tea we consume, but cannot be anything like so certain about potatoes. In the same way, we know exactly—or almost exactly—how much money goes into football pools, the dog tracks and the Tote, but can only guess at the volume of betting with bookmakers. I doubt if in fact complete statistics on this point can ever be obtained. The most exhaustive "sampling" methods will not produce an accurate result, because you are dealing with what many regard as a vice, and those interested are no more likely to tell you everything than they would if your inquiries were concerned with drunkenness or immorality. Hence the tendency of those who deplore gambling on moral grounds is to play up its economic significance, while the tendency of the bookmaking fraternity is, equally naturally, to play it down.

Before I come to Mr. Peterson's discussion of football pools—in which I am particularly interested—there are three points I should like to make. The first concerns the social significance of gambling. This can, I agree, be much exaggerated. The number of homes that are ruined by betting is surely much smaller than the number ruined by drink. At the same time, its economic effects are not negligible. Assume that ten million wage-earners spend, on average, about half-a-crown a week on the football pools. Only a small proportion of them—perhaps 3 per cent.—get their money back, for the proceeds of their gamble are very unequally distributed. This means—as it seems to me—that football pools have become in actuality a significant item in the cost of living. I doubt very much if they should even be regarded as the wage-earner's marginal expenditure: if his income goes down by half-a-crown a week, does he first sacrifice his pools? If this is true—and I leave out of account the much larger volume of betting on horses—it is surely of some social significance.

Secondly, the net cost of gambling—considered from the national standpoint—is, in my opinion, greater than the Commission's figures suggest. They take into account the wages of those employed by the football pools and other gambling agencies. But surely they should also, logically, take into account the very considerable expenditure—primarily by the newspapers—on the provision of tips and information. Two London evening newspapers devoted two pages a week to the assessment of football prospects, not a line of which would appear were it not for the pools. Even greater expenditure is incurred in the provision of racing information, and this too is solely for the benefit of gamblers.

Exactly where one should draw the line in assessing the real cost of gambling it is hard to say. I know a number of reputable citizens who spend every afternoon during the flat racing season with their eyes glued to the tape. One cannot tell how far the community loses by this diversion of their efforts from more productive activities.

Finally, the Commission—very properly—ignored, as outside its terms of reference, the discussion of such activities as speculation on the Stock Exchange. None the less, much of this is gambling pure and simple. Successive governments have attempted—by the imposition of taxes and in other ways—to make such speculation unprofitable. But they have not succeeded, and are not likely to succeed as long as it is virtually impossible to make more than a bare living by any process which can be scheduled as gainful employment.

I now come to the second part of Mr. Peterson's paper, in which he discusses Appendix III of the Commission's report. This Appendix was based on the evidence which I gave to the Commission. And I am glad to have this opportunity of replying to some criticisms. The Commission go nearly all the way in accepting my conclusion: that there is no difference between a football pool and a lottery. I sought to show, by an exhaustive analysis of the available figures, that the whole business of studying "form", forecasting, permutations, and all the rest of it, is irrelevant to the final results, which are indistinguishable from the results that one would get in a lottery. To take, for example, the simplest pool—one where there are only four results to be forecast—there are 81 possible forecasts. Since approximately half the money subscribed goes in tax, expenses and profits, there is half of it available for redistribution. And I showed that, in the four results pools, approximately one entrant in forty shares the distributable dividend.

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But, if any appreciable element of skill were exercised, the punter—aided by battalions of newspaper experts—would, obviously, get better results than this. The consistent conformity of the results disclosed to those which you would get by purely random selection of your entries—and it does not matter what type of pool you investigate—affords, it seems to me, an unanswerable argument.

Admittedly, since it is logically impossible to prove a negative, one can never prove that no one who has won a football pool prize has brought any element of "skill" to bear. For that reason, a pool is not a lottery as our courts understand the term. At the same time, if I were an anti-gambling organization, I should endeavour to raise this issue in the courts, arguing it along the lines of my evidence to the Commission.

Two specific criticisms of my evidence were offered by the Commission, to both of which Mr. Peterson draws attention. One is the criticism that, in the case of the fourteen results pool, the second, third, fourth and fifth dividends almost always deviate from the norm to the same extent as does the first dividend. "Does not this", it was asked, "suggest some element of skill?" My reply is: most certainly it does not. For in this Penny Points Pool, the great majority of competitors submit multiple entries which are not haphazard, but conform to a so-called "permutation". Hence every first dividend tends to carry with it a number of smaller dividends. Thus, if I "invest" 10*s.* 8*d.* in the Penny Points Pool, nominating seven bankers and permutating my other seven entries each in two ways, I may well get, in addition to my first dividend, three or four second dividends; half a dozen third dividends; a dozen fourth dividends; and so on. Here is, I believe a complete explanation of the results to which Mr. Peterson draws attention.

The second criticism is this: that "it seems difficult to account for the large variations in dividends except by recognizing the existence of some other factor besides pure chance. It therefore appears that the fact that at least a proportion of competitors base their forecasts, not on random selection, but on their judgment of the probable results of the matches, does . . . have some effect on the dividends declared" (p. 175, para, 25).

This comment is easily answered. By "judgment" is meant acceptance of the published opinions of newspaper experts. Sometimes they are right, sometimes they are wrong: I showed in my evidence that purely random forecasting gave results precisely comparable to those of the best-publicized experts. Now let me offer an analogy. Suppose that, instead of forecasting so many matches, one were asked to forecast, week by week, whether four cards drawn from a shuffled pack would be hearts, diamonds, spades or clubs. Suppose that the newspapers—egged on by interest in the large prizes offered—devoted space every week to publishing "expert" opinion as to what cards would be drawn. Suppose these opinions were widely followed. There would be weeks when the "experts" would be near the mark; there would be weeks when they would be far away from it. In the former case the prizes would be small; in the latter, large. This seems to me to be an exact analogy, for the experts get no better results when they are trying to forecast wins or draws than they would get if they tried to forecast hearts or clubs. Where, then, is the element of skill?

In short, in making the criticism I have cited, the Commission has, apparently, introduced the assumption that skill is relevant, to explain results which can better be explained by ignoring it. The whole of the results which we have been discussing—widely as they may vary from the theoretical norm—are entirely consistent with the laws of chance. The point overlooked—and in my evidence I failed to stress it sufficiently—is that there is, in this particular field, a twofold application of the laws of random selection. There is the random occurrence of a complex of unforeseeable results and, within this framework, the random application of competitors' guesses.

I have very great pleasure in congratulating Mr. Peterson on his paper and in moving a vote of thanks.

Mr. Tetley (in seconding the vote of thanks): I confess that my first reaction on reading this paper was a feeling of disappointment that the author should have confined himself to more or less factual reporting on two sources of data without attempting to develop any theoretical ideas. On a closer examination of the two documents, however, I came to the conclusion that he was probably very wise in resisting the temptation to erect an elaborate superstructure on some rather shaky foundations.

There are one or two questions of detail I should like to deal with in the first instance. I feel that there is a fallacy in the author's statement (on the economic significance of gambling) that, "in the circumstances" he quotes, the relation between the amount received by each gambler in the form of winnings and his total stakes will "over a sufficiently long period of time" approximate to the relation between the stakes and winnings of gamblers as a whole. I should have

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thought that this would apply "over a sufficiently long period of time" whatever the odds, long or short. What, I think, the author means is that when the odds are "short" that position will be attained over a relatively short period of time, and that wide divergences from the average are much less likely to occur.

My next point concerns the tables given in the Annexe. In Table 5 the left-hand section is based on an analysis of Sherman's pools which, I am told, tend to operate in a rather restricted geographical area, namely, the West Country and Wales, so that they may not be representative of football pools as a whole. In comparing the two sets of percentages two factors should be kept in mind. One is the tendency for two or more people to join together in submitting one coupon. That, one would imagine, would most affect the higher denominations of coupon. In the lower denominations, on the other hand, many competitors submit two or more coupons each week. It is difficult to form any estimate of the extent to which those two factors cancel each other. Obviously the two sets of percentages must cross somewhere, and it is equally obvious that that crossing must take place in the group "1*s.* up to 2*s.* 6*d.* inclusive" where nearly half the total frequency is concentrated. Consequently the approximate agreement of the percentages in that group seems almost inevitable.

In the other groups it is rather less satisfactory. Where the amount staked on a coupon is 1*s.* or less the proportion is less than 40 per cent. of the corresponding figure based on individual stakes. For the range 2*s.* 6*d.* to 6*s.*, however, the percentages based on coupons are nearly double those based on individuals. These ratios seem rather extreme. I cannot agree therefore with the statement in the early part of the paper that there is "close correspondence" between the information derived from these two sources—Sherman's Pools and the Social Survey—or that this correspondence "confirms the accuracy of the Social Survey figures." I would rather say that the ratios are rather surprising, but allowing for the unknown effect of the two factors I have referred to, it is impossible to say whether the two sets of percentages are, or are not, consistent.

I hope the author was not responsible for Table 5, because it is an almost perfect example of how such a table should not be drawn up. It is obvious that multiples of sixpence are of the utmost significance in this analysis, and this was taken account of in the Social Survey report where the figures for stakes of exactly 1*s.* and exactly 2*s.* 6*d.* were tabulated separately. Here the limiting values are included in the groups and not on any consistent principle. In the first two groups the upper limit is included, not the lower. The fourth group starts at "over 4*s.*" where the previous one stops at "under 4*s.*", so that stakes of exactly 4*s.* are apparently excluded. On reference to the Social Survey figures it is clear that in actual fact 4*s.* is included in the upper of the two groups, so that we now have the lower limit brought in instead of the upper. The same applies to the group "6*s.* and over." There the table should have ended, but as it is printed it appears that the final two items, "over 10*s.* to 20*s.*, 2·72 per cent.", and "over 20*s.*, 2·11 per cent." are additive to those above. They are not, of course, and the table ends at "6*s.* and over". Those two items are really subdivisions of the previous group. Incidentally why are the proportions shown to two places of decimals when, in the rest of the table, where the numbers are bigger, they are given to one place only?

Passing now to Table 17, I think the author was less than fair to the Royal Commission when he said that in constructing this table it was assumed that the same amount was staked on every runner. That is a most unreal assumption to make because the odds are almost entirely determined by the relative amounts staked on the different runners in a given race. Actually it was assumed that *for a given range of odds* in this table, say 7—4 to 9—2, each of the runners had the same amount staked on it. That assumption is very much more reasonable, and would not invalidate the conclusion. Finally, in arriving at the overall percentage of bookmakers' profits, due allowance was made for the relative weight of the stakes at the different levels of odds. In other words, the percentage in the last line, 20, is rather misleading.

In constructing Table 20 the data for 36 dates were arranged, not in chronological order, but first those with one home win, then going on to two home wins, and so on, up to nine home wins, and finishing with two special cases in which one match was cancelled. In the present paper the author has taken the results for the first six dates in the full table and those for the last six dates thus cutting off the two "tails" of the distribution. He might, by taking every third date, have obtained a more representative impression of the entire table as set out in the Report of the Royal Commission and would have avoided giving a misleading impression. The discrepancy ratio is positive for the vast majority of cases illustrated in this truncated table, but if one examines the intermediate section—more than two-thirds—as given in the Royal Commission's report one finds large sections where the discrepancy ratios are negative, and in fact the positives and negatives for that part almost cancel out.

Finally, Table 22 has been copied by the author too faithfully from the Report of the Royal Commission because it repeats a mistake which occurs in respect of the 22 points scored. In

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order to score exactly that number of points the competitor must have selected either 7 draws and 1 home win or 6 draws and 2 away wins. The first term in column 3 is correct for the number of ways of achieving the first result, but the second term should be ${}^cC_6 \times {}^bC_2$ or ${}^cC_6 \times \frac{1}{2}b(b-1)$; it is, in fact, exactly twice the correct value. This is not a mere misprint, as the same value appears in the last term of the denominator in column 4.

I fear there is a real danger that the Social Survey, which is now so well known and has produced such good results in suitable circumstances, will be invoked on all occasions, suitable or otherwise. I cannot help feeling that this was an occasion when it was very unsuitable. In the first place there is a tendency on general grounds to regard the inquirer as a Government "snooper" who must be got rid of as soon as possible. In the more restricted context of this inquiry, as Mr. Hubert Phillips has said, the whole question of gambling is bedevilled by religious scruples or prejudices and by the feeling of the typical suburban housewife that it is not "respectable"; I cannot feel therefore that many of the answers given were really of great value.

Obviously the timing of this inquiry was of great importance. Probably it was a question of Hobson's choice, but it was rather unfortunate that some of these questionnaires were completed just before and others just after the opening of the flat racing season. People were asked how many visits they had paid to a racecourse during the last seven days, and obviously very different answers would be forthcoming from the two sections. Those who had not visited a racecourse during the last seven days were asked about the last time they did so, and probably for a number of them it would be a long time before. There is a tendency whereby the more a person questioned has to exercise his memory the more likely he is to give an *average* answer rather than the actual facts. There is a real danger therefore that you are getting roughly the right mean, though your scatter or spread should be very much bigger than the answers would indicate.

There is one further point which I feel is rather serious. Those people who admitted to betting "off the course" were asked how they did so. The questions included: Do you bet with a street bookmaker, cash by post, through a friend, through someone at work, or through a tradesman? Now, all these methods of gambling are either definitely illegal or almost certainly illegal. It does seem to me a most undesirable development that an investigator acting under Government auspices should ask questions of the ordinary citizen which invite him to confess to illegal actions, however trivial and venial they may be. I need not draw attention to possible undesirable developments. As to the statistical value of these answers I cannot speak, but I was surprised to find how many people admitted to betting in cash off the course. The difference between this evidence and the evidence obtained in other ways was quite noticeable in places. One point was that about 30 per cent. of the people questioned said that they betted on horse-racing, but when they were asked whether they betted on certain classic races 44 per cent. said that they did so. There is a discrepancy there of about 50 per cent. Another question examined was the average totalisator bet on a horse race; according to the Social Survey this was "well under 10*s*." whereas the Royal Commission arrived at a figure of 14*s*., based on sales of totalisator tickets. I admit they thought this value rather on the high side but here again there was a discrepancy of about 50 per cent. Just one more comment. We all know that the word "sport" has become somewhat debased, and I wonder whether the last two questions in the form were deliberately put together. The group relates to miscellaneous forms of betting and the last two items are "Stock Exchange bets" and "Other sports"!

Although I have been rather critical of the paper I hope I shall not leave a false impression. I have greatly enjoyed reading it and I second the vote of thanks to the author with much pleasure.

The vote of thanks was put to the meeting and carried unanimously.

Mr. A. STUART said he would confine his remarks to a practical aspect of football pool betting.

As Mr. Phillips had said in evidence to the Royal Commission, the matches selected by football pools promoters for the Penny Points Pool were chosen for their difficulty. On 51 occasions in the past and present football seasons, for which he (the speaker) had been able to find complete records, the distributions of home wins, away wins and drawn matches were as follows:

	Matches included in Littlewood's Penny Points Pool	*Other first-class matches*
1	298 = 42%	1,358 = 56%
2	270 = 38%	526 = 22%
X	146 = 20%	543 = 22%
	714	2,427

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These tables showed that Mr. Phillips's main point, that it is impossible to forecast drawn matches with any certainty, seemed to apply just as much to pool-setters as to pool-punters: the matches they selected differed very little from others in the proportion drawn, although they contained a substantially higher proportion of away wins.

The first of these tables confirmed what was known to some punters: that home wins, away wins and drawn games do not occur equally frequently among the results of this Pool. We could establish this by noticing that, under the hypothesis of equal frequencies, the number of points scored on any occasion was a random variable with mean value 28 and sampling variance $\frac{28}{3}$. The mean of 51 such variables would have the same mean value, and a sampling variance of $\frac{28}{3 \times 51}$. The observed mean points scored for these 51 weeks was 25·02, and the difference of 2·98 therefore represented a deviation of about seven standard deviations from the expected value of an approximately normal distribution. The hypothesis might therefore confidently be rejected.

Using this table the statistician could offer the Penny Points Pool punter a certain amount of guidance. If he made his forecasts at random, subject to the restriction that he finished up with 6 home wins, 5 away wins and 3 draws in every entry submitted, he would probably be doing the best he could. There were 168,168 ways of forecasting 14 matches subject to this restriction, so that there was plenty of room for variation in the entries submitted. He did not suggest that punters would necessarily win prizes by this method, but those among them with an aesthetic sense would at least have the satisfaction of knowing that their losses had been incurred in an efficient manner.

The Rev. BENSON PERKINS said he felt a good deal of surprise that the first really serious statistical figure produced when the Betting Committee was set up in 1923 should have encountered some depreciation. The Statistical Department of the Board of Inland Revenue went to considerable trouble to produce an estimate which the Chairman in his draft report accepted, and the Royal Commission of 1932 felt was a sound figure. That figure of £200 m. was discounted in the report of the Royal Commission of 1951 on the ground that after the betting duty was introduced in 1926, the peak figures for that year and the years immediately following showed that betting duty was paid on a turnover of £48 m. for betting on the course and about £49 m. for betting off the course, or nearly £100 m. altogether. The 1951 Report in Appendix II stated that it was unthinkable that there could be 50 per cent. evasion. He believed that comment was quite unjustified. A prominent official of the Inland Revenue assured him that evasion of 50 per cent. could take place, and if anything like that was incurred a turnover of £200 m. was within sight. In the first report of the Racecourse Betting Control Board their turnover figure was £230 m. for the year 1929.

He thought the author did scant justice to the Churches' Committee on Gambling in saying that in reaching a much higher turnover figure than the Royal Commission felt it could support it took that figure of £200 m. and simply allowed for change in money values. That was not so. That figure was tested every year from the available facts. Later there came in the hard figures quoted, but there were also certain social facts that appeared very materially to affect these turnover figures. Admittedly they were approximate, and even now the sort of figures given in the paper, as the author had pointed out, should be taken as being within a broad margin of error.

A further comment might be made on what was said in the paper on the economic significance of gambling. A reference was made to "personal expenditure" and that part of it which was represented by gambling. This was calculated as being the cost of the organization of gambling and the taxation of gambling. The phrase "personal expenditure", however, was an entire misnomer; it was actually "net cost". Personal expenditure must take account of redistributed money. The cost of organization and taxation was taken out of gambling before there was any distribution, whatever method was being used, whether horse or dog racing or pools. "Personal expenditure", so called, on gambling was then compared in the paper with personal expenditure on other items. He submitted that that was a quite unwarranted comparison. Gambling was not the purchase of a commodity. It was a re-distribution of money in various ways, and to compare it with the purchase of commodities which figured in ordinary personal expenditure was to compare like with unlike.

When it came to a question of redistributed money the author had referred to a comment of the *Manchester Guardian* on the argument of the Commission that, since gamblers sometimes won, the national total of winnings must be offset against the national total of stakes, and that only the difference could be reckoned as personal expenditure. It was suggested that if redistributed

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money in winnings was to be regarded the £70 m. a year which was the Commission's estimate of "personal expenditure" on gambling might be raised to £150 m. or more. What he thought was open to very serious criticism was the statement that if £150 m. was accepted as representing approximately the amount which gambling cost to those who took part in it, the burden which gambling imposed on the standard of living of the average gambler was not very large, the average maximum loss being in the region of £10 annually. If that was an accurate figure it was the debit balance at the end of the year, but it was not the expenditure. The actual relationship of that figure to the expenditure of the gambler was quite different, if that figure was applicable at all If a man was gambling he was likely to be staking money week by week. The Social Survey gave the average weekly stakes of those betting with credit bookmakers as £3 10*s.* 0*d.* Sometimes they won. They went on staking the money week by week, quite often day by day, and this continuous outgoing was intimately related to what they spent on items of personal and family consumption and to their standard of living. At the end of the year there might be only £10 on the wrong side, but that £10 was not the sole expenditure nor really related to the social effect of gambling on the standard of living.

It should also be noted that winnings which came in this way were not used with the same sense of responsibility as ordinary earnings. The late Lord Stamp, a previous President of the Society, in giving evidence before the Royal Commission in 1933, pointed out that if there were two men who had more or less equal incomes, one of them using the income in the normal way for personal and household expenditure, and the other using part of his income for gambling, even though they might break even at the end of the year they had each a quite different relation to the economy of the country. The fact that a balance could be drawn at the end of the year did not express the real position or form the basis for a true judgment.

He wished to say how much he had appreciated the paper.

Mr. A. W. Peterson accepted the invitation of the President to defer his considered reply until he could make it in writing. With regard to Mr. Phillips's remarks about the Royal Commission's criticisms of the evidence he might be allowed to say just this: that any Royal Commission must be rather a cautious body. Here were twelve people seeking to arrive at a unanimous report, and therefore the report did tend to be a qualified document. But he might read the conclusion of the report on Mr. Phillips's evidence.

Mr. Peterson here read the extract. Mr. Phillips's evidence was to the effect that football pool forecasting was nothing but a lottery. The Commission was not convinced that in all respects his evidence succeeded in establishing this fact. Nevertheless, his evidence showed clearly that the difficulties of forecasting correctly the results of a large number of matches were so great that the number of prize winners was determined rather by the laws of probability than by the skill of the competitors. "Although there is room for the exercise of judgment it is possible to win prizes without attempting to assess the chances of the team."

He was very grateful to those who had spoken and to the Society in general for their reception of his paper.

Mr. Peterson subsequently replied in writing as follows:

I should like to thank Mr. Tetley for his criticisms of some of the figures taken from the Report of the Royal Commission which were reproduced in my paper. As Secretary of the recent Royal Commission I have some responsibility for the way in which the statistical material was presented, but in many cases (as, for example, the analysis of Sherman's Pools in Table 5) the form in which the figures are given in the Report was dictated by the form in which the material was submitted to the Commission. In Table 17, which was reproduced from an article in a magazine, the figures given in the last line are in fact based on the assumption that the same amount was staked by every runner, and it is pointed out in the Report (Appendix II, paragraph 49) that for the reasons mentioned by Mr. Tetley the percentage figure given in that line is misleadng. I agree that the method of selecting specimen results from Table 20 suggested by Mr. Tetley would give a more representative impression of the entire table, and I am obliged to him for pointing out the error in Table 22.

I cannot, however, agree with his criticisms of the usefulness of the Social Survey results, which are supported to some extent by Mr. Phillips. Gambling is obviously a difficult subject to investigate by these methods, and that fact is fully recognized in the Report of the Social Survey, in the Royal Commission's Report and in my paper. But there is very little evidence for the view that the answers given cannot be relied on, and where the results can be checked, as in the case of football pool betting, there is clear evidence to the contrary. Mr. Tetley's objection to the inclusion in the questionnaire of questions about forms of betting which are illegal raises an

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interesting point about the general conduct of Social Survey investigations, which it would not be appropriate for me to discuss here. I would, however, like to make just two observations. The first is that it is not in fact illegal to place bets by most of the methods which he mentions. The offence is committed by the bookmaker who accepts the bet, and not by the person who makes it. Many people who bet in cash by post are probably quite unaware that the bookmaker commits an offence by accepting their bet. The second point is that no inquiry into betting off the course which ignored illegal betting would be of the slightest value. It has been well known for many years that a very large number of those who bet off the course do so by means other than the only means which the law allows (i.e., on credit terms and without visiting the office of the bookmaker). It was for this reason that the Royal Commission's terms of reference required them to investigate not only the law, but the practice relating to betting. In considering whether the law prohibiting cash betting off the course should be altered, it was of the greatest importance to the Commission to discover the present extent of illegal betting. There are only three possible sources of information—the police, the bookmakers who carry on illegal businesses, and those who bet with them. The police can give only a general picture of the extent of illegal betting, and the bookmakers for obvious reasons are not likely to be informative. The Commission were therefore very fortunate to have access to information obtained from the bettors themselves. Whatever views may be held as to the precise reliability of this information and of the desirability of investigating illegal practices by this method, which in any case is dependent on the willing co-operation of the bettors themselves, its value as a contribution towards the study of this very difficult social problem should not be under-estimated.

As a result of the ballot taken during the meeting the candidates named below were elected Fellows of the Society:

John Hunt Austin.
Valerie Edith Brown.
Kenneth Norman Chandler.
Kenneth Harold Coombs.
William Anderson Donaldson.
Ethel Helen Laing Duncan.
Tariniprosad Ghose.
Arthur Thomas Gore.
Peter Gwynne Grundy.
Rona Geneva Gundry.
Stanley Francis James.
William George Arthur Jenkins.
Walter George Jones.
William Arthur Lewis.
John Walter Charles Love.
Robert Charles Paton.
Harold Edwin Styles.
Dinker Ghelabhai Vashi.
Noel Williams.

Corporate Representatives

Alun Evans Jenkins, *representing* The Mond Nickel Co., Ltd.
William Charles Wake, *representing* The Research Association of British Rubber Manufacturers.

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Contiguity and Deadly Quarrels: The Local Pacifying Influence

By Lewis F. Richardson

1. *Summary and Outlook*

The design of a new machine is not entirely free, for it has to conform to the laws of dynamics. Similarly in politics, any new proposal for decreasing the frequency of wars should be judged in view of what usually happened in the past. The present treatment does not go so far as to discuss "what ought to be done" (i.e., political planning), but is restricted to the preliminary question "what has usually happened" (i.e., social dynamics).

It is shown in section 7 that some strong pacifying influence has prevented small-scale fighting, and in section 8 that civil fighting has been prevented more than foreign fighting. What is offered here is not a surmize based on general impressions, but statistical proofs. A statistical technique which the author devised in 1943 for the study of the alleged pacifying effects of common language or common religion (1950*b*, pp. 317–373), was afterwards applied by him to the simpler question about common government (1950*a*, pp. 31–32). Although he still believes that those previous attempts were crudely correct, he has since improved them, and now wishes to explain.

Since 1914 there has been a slow, diffident and fluctuating drift towards world-government. If, in the future, world-government were to become the norm, then any subsequent wars would have to be called civil. It is well to be prepared for this situation by studying now the causes of civil wars.

The existence of a pacifier is here proved, but its nature is not entirely clear. It may well be the habit of obedience to a common government. But there are several other social features which have positive correlations with common government, so that their pacifying effects could easily be confused with those of government. Such are: intermarriage, common language, common religion and the tendency to direct one's hatred on to foreigners. Some of these have been examined elsewhere. By statistical methods no general pacifying effect was found for either common language or common religion; but particular effects, either pacificatory or bellicose, were found to be connected with particular languages or religions, notably pacificatory with the religion of China before the revolution of A.D. 1911, and bellicose with the Spanish language (Richardson, 1950*b*). It is more difficult to distinguish the effects of intermarriage from those of common government (Richardson, 1950*a*).

In the sequel the word "pacifier" is used merely as an abbreviation for "pacifying influence".

2. *Preliminaries*

The essence of statistics is counting. Wars, having been of such different sizes, cannot suitably be counted until they have somehow been arranged according to their importance. The measure of importance which is here adopted is the number of war-dead on both sides jointly. This concept extends readily to the smaller deadly quarrels, which would not ordinarily be called wars. The "magnitude", μ, of any deadly quarrel has been defined to be the logarithm to the base ten of the number of those who died because of that quarrel (Richardson, 1941 and 1948*a*). For examples: the Second World War was of magnitude $7{\cdot}_4$, the North American Civil War was of magnitude $5{\cdot}8$, the Seven Weeks' War was of magnitude $4{\cdot}6$, the Boxer Rising was of magnitude $4{\cdot}_2$, the annexation of Hyderabad by India was of magnitude $3{\cdot}3$, Louis Riel's rebellion in Saskatchewan in 1885 was of magnitude $2{\cdot}3$, and examples might be continued down to a murder of magnitude $\log_{10} 1 = 0$.

The historical facts must be numerous enough to yield a statistically significant summary. The necessity for a large sample competes with the desire to be up-to-date. One has to rely on the belief that, although human nature may change, yet it changes slowly, so that an interval of recent history may contain lessons for to-day. The interval actually chosen for study here began with A.D. 1820.

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The sample must also be unbiased. Because the chief sources of bias are national, the facts have been collected from the whole world (Richardson, 1950*b*). The particulars of any war were selected after consulting sources of information which were, if possible, either neutral, or of opposite sympathies.

A deadly quarrel is here called civil when the contestants owed allegiance to a common government immediately before the outbreak.

3. *Pairs of Opposed Belligerents*

Some wars have been partly civil and partly international. To obtain a clean-cut statistical classification it is preferable to count, not wars, but pairs of opposed belligerents. A belligerent is usually a group of people, such as a nation, or a group of insurgents. By exception the victim of a murder may be a single person.

Table 1 is partly a quotation from a microfilm (Richardson, 1950*b*, p. 287), where much fuller explanations and particulars can be seen; but the numbers have been revised and subdivided.

TABLE 1

For Deadly Quarrels that Ended Anywhere in the World from A.D. 1820 *to* 1945 *inclusive*

Ends of Range of Magnitude, μ, of the Whole Quarrel	*Pairs of Opposed Belligerents*			*Ratio of Civil Pairs to Total Pairs*
	Civil	*Foreign Contiguous*	*Foreign Non-contiguous*	
$7\pm\frac{1}{2}$ (world-wars)* . .	12	40	71	0·10
$6\pm\frac{1}{2}$	3	8	14	0·12
$5\pm\frac{1}{2}$	23	59	7	0·26
$4\pm\frac{1}{2}$	49	100	42	0·26
$3\pm\frac{1}{2}$ (incomplete collection) .	129	114	39	0·46
$2\pm\frac{1}{2}$ { systematic collection } .	—	—	—	—
$1\pm\frac{1}{2}$ { wanting } .	—	—	—	—
$0\pm\frac{1}{2}$ (murders) . . .	—	—	—	1·0

* Neglecting some minor incidents, but counting everything in the so-called "matrices".

World-wars have been mostly international; murders have been nearly all civil; the intermediate deadly quarrels show a fairly regular gradation between these extremes, as may be seen in the last column of Table 1.

4. *The Importance of Contiguity*

The obvious reason why the murderer and his victim were usually subjects of a common government is their localization. Presumably an extension of the same notion, namely the more extensive geographical contacts of the more populous belligerents, would also explain the ratio of total to civil for the other magnitudes. For it has been shown that the number of a State's external wars has a positive correlation of 0·77 with the number of its frontiers (Richardson, 1950*a*, p. 31, or more fully 1950*b*, pp. 263–8). The importance of contiguity also became conspicuous in a research on the number of nations on the two sides of a war (Richardson, 1947), for the statistics were explained by a chaos, restricted by geography, and modified by the local infectiousness of fighting.

These three lines of evidence show that, as a preliminary to estimating the pacificatory effects of common government, or common language, or common religion, it is necessary to prepare a suitable measure of the geographical opportunities for fighting. This measure must apply to the whole world, and must somehow be related to the number of those who died because of the various quarrels. In previous publications the author has offered different crude approximations suited to different purposes.

In order to study the effects of contiguity they must be separated from those of long range power, whether air power or sea power. This is done by alternative methods. In section 7

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the sea power receives attention by particulars of navies and by maps; whereas the air power is mostly eliminated by ending the historical interval with A.D. 1929, as in Table 5. The same purpose is attained differently in sections 6 and 8 by specifically excluding foreign non-contiguous quarrels; and when that is done there is no objection to extending the time interval, as in Tables 3 and 9.

5. *A Fundamental Assumption about Those who Did Not Fight*

Any search for pacifying influences must take account both of those who fought and of those who did not. The deadly quarrels have been classified by the number of quarrel-dead or by its logarithm, the "magnitude." Those who did not fight are specified by the number alive. So a statistical link between "magnitude" and population is required. An alternative plan would be to ignore the quarrel-dead, and to classify the actual quarrels instead by the populations of the opposing sides. However, if that were done, the number and the varieties of actual quarrels would become vague and uncountable, because the newspapers of any one nation are usually complaining bitterly about the conduct of some other nation. The author regrets that he sees no escape from the need to make an assumption to connect populations with casualties in quarrels that are hypothetical. The assumption must of course be founded on fact.

The amount of sufferings at the time of defeat can be crudely expressed by reckoning the war-dead as a percentage of the pre-war population. This is done in Table 2. The column marked "Ref." indicates the source of the information about losses of life. The percentages have been rounded off, because the number of war-dead is usually very uncertain. Some of the dates also may not be quite suitable. Belgium is suitably taken at the end of 1914 about two months after it was overrun; but Serbia had to be taken at the general armistice of 1918, because the record of its casualties up to its defeat in 1915 was not found separately. Another uncertainty is whether casualties should be allocated to an empire or to its metropolitan core. Nevertheless, when Table 2 is viewed as a whole, a statistical distribution appears, having its median at $1\cdot_4$ per cent., and its quartiles at $0\cdot_3$ and $2\cdot_9$. During the interval A.D. 1820 to 1945 there were far more defeats than the 22 shown in Table 2. It does not seem possible to collect them all, nor to assert that Table 2 is a fair sample. The author, however, has not wittingly introduced any bias.

Defeat may of course have depended on many considerations other than past or present sufferings. The Russians in 1905 made peace partly because they had only one railway line to the site of their conflict with Japan. Austria in 1859 listened to reasonable terms of peace. Reasonable offers of peace, however important they were on some occasions, cannot be taken into account in the present treatment, because it is restricted to be simply numerical. Moreover it is noticeable that nations which had been thoroughly roused by fighting, but were not yet overcome by exhaustion, have sometimes been remarkably unwilling to attend to terms of peace; so that the war came to an end by sufferings, and not by intelligent compromise (Richardson, 1948*b*, pp. 158–9).

TABLE 2

War-dead as a Percentage of the Whole Population, at or after Over-running or Defeat

War-dead per cent.	*Nation*	*Date*	*Ref.*
⩽83	Paraguay	1870	E, **17**, 259.
⩽22	Serbia	1918	Yovanovitch.
4	Germany	1945	K 7508.
3·1	Roumania	1918	Huber.
3·0	Austr.-Hung. Emp.	1918	Huber.
2·9	Southern U.S.A.	1865	Rhodes.
2·8	Germany	1918	Brockhaus, **20**, 193.
2·35	Holland	1945	K 9579.
2	Turkish Emp.	1918	Emin.
2·0	Bulgaria	1918	Danaillow.
1·6	Boers	1902	E, **21**, 66.
1·2	Japan	1945	K, 7837.
0·93	Russian Emp.	1917	Kohn.
0·9	Italy	1943	K, 7784.
0·5	France	1871	Dumas.
0·5	Finland	1939	K, 4089
0·3	Peru	1879	Dumas.
0·12	Belgium	1914	Otlet.
0·11	Denmark	1864	Dumas.
0·09	Russia	1854	Dumas.
0·04	Russia	1905	Dumas.
0·03	Austro-Hung.	1859	Myrdacz.

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With Table 2 in view it seems reasonable to make the following assumption about hypothetical wars:

If two contiguous groups of people began to fight one another, they would, if not restrained by external authority, go on until one side was defeated; and defeat would usually occur when the less populous side had lost in dead some number between 0·05 and 5 per cent. of its population, while the larger population having sustained about equal casualties, would therefore have lost a smaller percentage . . . . . (1)

Accordingly the total war-dead of both sides together would be from 0·1 to 10 per cent. of the smaller population. To put this assumption into symbols, let h be the lesser of the two opposing populations, and let μ be the magnitude of the hypothetical deadly quarrel, then

$$\mu = \log_{10} h - j, \quad \text{where } 1.0 < j < 3.0. \quad . \quad . \quad . \quad . \quad (2)$$

The median of $1\cdot_4$ per cent. in Table 2 corresponds to $j = 1.6$. . . . . (2*a*)

In subsequent abstract models the groups of people who might have fought, but did not, are imagined to occupy cells of equal population, h. The qualification "lesser" is then not needed.

There may be a feeling that the assumption about hypothetical quarrels should agree more closely with fact. Instead of assuming, as is done in sections 7 and 8, that j is independent of μ, would it not be more correct to plot the observed $\log_{10}h$ against the observed μ, to fit the plotted points with a line for predicting h when μ is given, and to accept this prediction-line, instead of the relation (2), as the fundamental assumption about hypothetical quarrels?

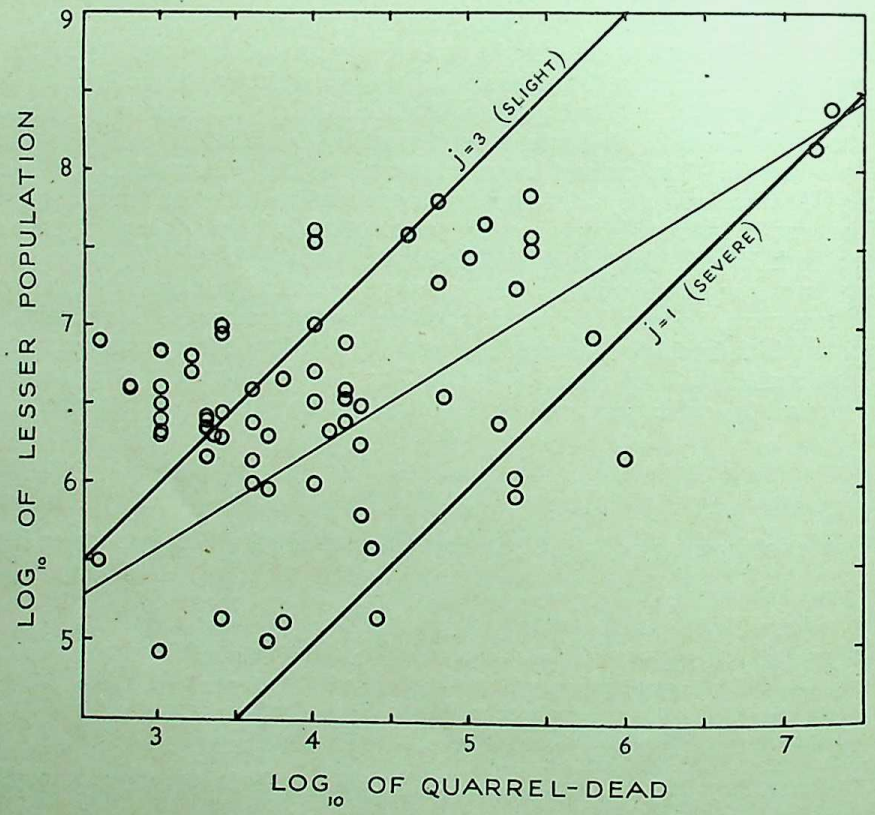

FIG. 1.—Casualties and defeat.

Fig. 1 shows an attempt to do this. The deadly quarrels were those in the author's list, which begins with A.D. 1820 (Richardson, 1950*b*). In order to gather enough facts, wars involving any number of belligerents were included, provided that they were, in the main, arrangeable as between

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two sides. Thus the two world wars appear on the diagram in the right-hand upper corner. Quarrels were excluded if the uncertainty either of μ or of $\log_{10}h$ appeared to exceed 0·3. This is only a small fraction of the range of scatter shown on the diagram. One might hesitate as to whether to take the population of the defeated side, or of the less populous side, for occasionally the larger population was defeated. I have chosen the less populous side. If this be an error of judgment, it will make a subsequent argument all the stronger. Moreover the lesser population was definite even when there was no definite victory and defeat.

Assumption (2) is shown on the diagram by way of the lines sloping at 45° for $j = 1$ (severe sufferings) and for $j = 3$ (slight sufferings). The band between these lines does indeed include a majority of the observed points for $\mu > 3{\cdot}5$; but for $\mu < 3{\cdot}5$ the band is too low. Some or all of this misfit near $\mu = 3$ is probably not a fact of history, but is merely caused by lack of information. The populations of sovereign states can usually be found in such books as the *Almanach de Gotha* or the *Statesman's Year Book*; but the populations of rebellious fractions of states are usually much more difficult to find. This may cause a bias; because for given μ, the known populations are likely to be larger than the unknown. Moreover the lack of information was most selective around $\mu = 3$, as the following table shows:

Ends of range of magnitude, μ .	$3\pm\frac{1}{2}$	$4\pm\frac{1}{2}$	$5\pm\frac{1}{2}$	$6\pm\frac{1}{2}$	$7\pm\frac{1}{2}$
Quarrels ended A.D. 1820 to 1949 .	198	68	25	6	2
Number of quarrels on diagram .	23	25	13	2	2

Consequently the lack of information is likely to have tilted the prediction line, making it slope less steeply than it would have done had the information been complete.

Suppose, however, for the sake of argument, that some future team of investigators were to succeed in finding the populations of all the insurgent groups; and that in consequence the line for predicting $\log_{10}h$ from given μ were found to slope less than 45°, as suggested in the figure. *The slope of such a line would by itself provide a proof of the existence of a local pacifying influence.* For the great wars cluster about the line $j = 1$, which corresponds to severe suffering, whereas the very small wars cluster about the line $j = 3$, which corresponds to much less suffering. Some influence, other than suffering alone, would then appear to have caused the less populous belligerents to cease from fighting. That is an interesting possibility for future investigation; but, because of the incomplete information, it is not yet proved.

For the purpose of investigating, by other arguments, whether a local pacifying influence exists, we should set out from the assumption that it does *not* exist (the "null hypothesis"). This is done in sections 7 and 8, by assuming j to be independent of μ.

6. *The Type One Versus One*

For simplicity the assumption (1) relates to a hypothetical deadly quarrel which involves only a single pair of belligerents. Among actual wars, that type has been fairly frequent (Richardson, 1947). The consequences of assumption (1) may suitably be compared with the historical facts relating to that type alone. When Table 1 has thus been pruned, it becomes Table 3.

TABLE 3

Deadly Quarrels, of the Type "One Versus One", that Ended Anywhere in the World from A.D. 1820 *to* 1945 *inclusive*

Ends of Range of Magnitude	*Number of Quarrels, alias number of Pairs of Opposed Belligerents*			*Ratio of Civil to Total*
	Civil	*Foreign Contiguous*	*Foreign Non-contiguous*	
$7\pm\frac{1}{2}$	0	0	0	—
$6\pm\frac{1}{2}$	3	0	0	1·0
$5\pm\frac{1}{2}$	6	3	0	0·7
$4\pm\frac{1}{2}$	10	15	2	0·3,
$3\pm\frac{1}{2}$	65	64	10	0·47
. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
$0\pm\frac{1}{2}$	—	—	—	1·0

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By comparison of Table 3 with Table 1 it is seen that the restriction to a single pair of belligerents has raised the ratio of civil to total, only in the larger magnitudes, where, however, the observed numbers are small. The middle portion of Table 3 will be quoted in Table 9.

7. *The Existence of a Local Pacifying Influence*

A proof of this has been developed from the study of the number of nations on each side of a war (Richardson, 1947, Theory XI) in the following manner. The historical facts were there compared with a formalized political geography consisting of:

α, world-wide sea-Powers which were in contact with so many other Powers by sea that their contacts by land alone could be ignored in comparison;

β, local coastal countries each touching the sea, also touching five different states by land;

γ, land-locked countries each touching five different States; where $\alpha = 5$, $\beta = 44$, $\gamma = 11$, total 60 countries . . . . . (3)

The probability p of war between any two named nations was there defined to be the fraction of any very long historical interval during which such war occurred. Therefore $0 \leqslant p \leqslant 1$. According to the geographical situation of the two named nations, p was given the different symbols specified in Table 4.

TABLE 4

Scheme

Members of the Pair	*Symbol for the Probability* p
(i) Two world-wide sea-powers	x.
(ii) A world-wide sea-power and a local coastal power	y.
(iii) Two local coastal powers . . .	z if in contact, or if a local belligerent touched both, otherwise zero.
(iv) A local coastal power and a land-locked power	
(v) Two land-locked powers . . .	
(vi) A world-wide sea-power and a land-locked power	zero, unless a local coastal belligerent put them in contact, when p becomes y.

The historical wars were sorted into types "r nations versus s nations", and these were further sorted into subtypes according to the number of long-range or local powers severally among r and s. It was found in fact that the most frequent subtype was a war between only two powers, both of them local. This subtype was briefly indicated by the symbol "0,1 versus 0,1". The "expectation" of a war of any subtype was defined to be the fraction of the historical interval during which such a subtype would probably occur. This fraction may conceivably exceed unity. Let the expectation here be denoted by ψ. The argument was modelled on Bernoulli's concerning the binomial. For the subtype 0,1 versus 0,1 it gave the following formula for the expectation:

$$\psi = \tfrac{5}{2}(\beta + \gamma)\, z\, (1 - y)^{2\alpha\beta(\beta+2\gamma)/(\beta+\gamma)^2}\, (1 - z)^{12} \quad . \quad . \quad (4)$$

The author still regards that as a valid rough approximation for its original purpose, namely the discussion of wars between known principal countries, all magnitudes from 7·5 to 3·5 being lumped together.

Now however the purpose is quite different, and the treatment must be appropriately modified. The magnitudes are to be separated into unit ranges, and are to extend down as far as possible. In these circumstances the conceivable belligerents are not only or mainly the sovereign states. It is more appropriate to think of cells of equal population h. Each cell may still be conceived as having contact with about five neighbouring cells. As the magnitude diminishes, β and γ must increase. Let W denote the population of the world. Then W/h is the number of cells in the world. So let

$$\beta + \gamma = W/h. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

It will suffice to take for W a mean value over the 110 years in question. The mean was computed from the data published by Carr-Saunders (1936), and was found to be

$$W = 1{\cdot}4 \times 10^9 \text{ persons.} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

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The fundamental assumption (2) as to the relation between population and casualties gives

$$h = 10^{\mu+j} \qquad \text{where } 1{\cdot}0 < j < 3{\cdot}0. \quad . \quad . \quad . \quad . \quad (7)$$

Elimination of h and of W leaves

$$\beta + \gamma = 1{\cdot}4 \times 10^{9-\mu-j}. \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This is ready for insertion in the formula (4) for ψ.

It will next be shown that the long-range powers can be dropped out of consideration. None of them fought in these purely local wars; nevertheless the probability that they remained neutral appears correctly in the formula for ψ as a bracket $(1 - y)$ having an index involving α. In the former study this probability was

$$(1 - 0{\cdot}00166)^{9{\cdot}6} = 0{\cdot}984.$$

In the smaller magnitudes it seems likely that y may be less than $0{\cdot}00166$; also that α may remain at 5. In the index the coefficient of 2α is

$$\beta\,(\beta + 2\gamma)/(\beta + \gamma)^2 = 1 - \gamma^2/(\beta + \gamma)^2,$$

and so lies between 0 and 1. When the cells become small, γ predominates over β; and so the index tends towards zero. The probability that the long-range powers remained neutral is therefore near to unity and can be omitted from (4). With these modifications, formula (4) becomes

$$\psi = \tfrac{7}{2}\, 10^{9-\mu-j}\, z(1 - z)^{12} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

For comparison with this formula, the historical facts previously published in "Collection J" are now slightly revised and sorted by magnitudes in Table 5.

The sorting by magnitude introduces a new problem; for in order to correspond with assumption (1), the war-dead should be those of the single pair of belligerents only. In the former publication (Richardson, 1947) they were not so entirely. For example in 1875 a war began between the Turks and the Christians in Herzegovina and Bosnia. This may suitably be regarded as of the subtype 0,1 versus 0,1; and it continued like that for 0·8 year. It would be difficult or impossible to find the record of casualties for that 0·8 year by itself. Later the Montenegrins, the Serbs and the Russians joined in the war, the magnitude of which grew to $5{\cdot}_4$. But the portion which was of the subtype 0,1 versus 0,1 must have had a lesser magnitude.

This difficulty will be surmounted by an over-proof, alias an *a fortiori* argument. The durations in the column of Table 5 headed "in parts of wars" may perhaps properly belong to a range of magnitude lower than that to which they are there assigned. The author does not know whether this is so, nor how much lower. Let these loose pieces therefore be either left where they are, or moved to a lower row, in such a manner as most to oppose the conclusion at which the subsequent argument arrives. This is done by making the aggregate duration increase as rapidly as possible as the magnitude decreases. The result is the column 0, 17, 44, 77, in Table 5.

TABLE 5

Observed Aggregate Durations of Fighting, A.D. 1820 *to* 1929 *inclusive*

Ends of Range of Magnitude of Quarrel as a Whole	*Aggregate Durations of the Subtype* 0,1 *versus* 0,1			
	Total years	*In Parts of Wars, years*	*Reclassification most Adverse to the Conclusion*	
			Years	*Fractions of* 110 *years*
$7\pm\frac{1}{2}$	1 ?	1 ?	0	0
$6\pm\frac{1}{2}$	17	0	17	0·155
$5\pm\frac{1}{2}$	44	30	44	0·400
$4\pm\frac{1}{2}$	47	16	77	0·700

The history is now ready to be connected with the geography. In making the connection, we need to notice that the definition of the probability z tacitly involves the two ends of a range of

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magnitude. In the original paper this range corresponded roughly to "wars" in the popular sense; but here it is a unit range.

The numbers in the last column of Table 5 were equated to ψ in equation (9), and the equation was then solved for z. The computation is summarized in Table 6.

TABLE 6

Deduced Probabilities

Ends of Range of Magnitude	*Number of Cells in the World*			*Therefore the Probability z*		
	$j=1$	$j=2$	$j=3$	$j=1$	$j=2$	$j=3$
$6\pm\frac{1}{2}$	140	14	—	0·000,45	0·004,7	—
$5\pm\frac{1}{2}$	1,400	140	14	0·000,11	0·001,2	0·013
$4\pm\frac{1}{2}$	14,000	1,400	140	0·000,02	0·000,2	0·002

The last three columns of Table 6 show that whichever value of j is chosen, z decreases rapidly as μ decreases. That is to say, *the fraction of the total time, during which any particular pair of contiguous cells fought one another, was remarkably less as the cells were drawn smaller. This proves the existence of a local pacifier.* Its nature is not revealed by this argument. In particular no distinction has been made between civil and foreign fighting.

The only geographical feature which is involved in the conclusion is the number 5, which is assumed to be the number of neighbouring cells that touch each cell. This 5 appears in formula (4) in the coefficient 5/2; also the index 12 is connected with it. The existence of the local pacifying influence would still be evident if in those connections 5 were replaced by 6.

Some reader may perhaps object that magnitude μ is such an artificial concept that the probability z in unit range of μ is of slight sociological interest. Therefore nothing of any importance can be immediately inferred from the gradation of z shown in Table 6. The primary fact is not the magnitude μ, but the number of war-dead, $n = 10^{\mu}$. It would be more rational to reckon the probability, not per unit range of μ, but for each of the integers n. The author himself in a previous paper about the variation of frequency with magnitude came round to that point of view, although it considerably complicated the presentation of the data. But if n, not μ, is taken as the basis for probability, the gradation changes its direction. For the number of integers n in the range from $\mu_0 - \frac{1}{2}$ to $\mu_0 + \frac{1}{2}$ is about $2{\cdot}846 \times 10^{\mu_0}$. Let great Z denote the probability per integer of n. The probabilities of the $2{\cdot}846 \times 10^{\mu_0}$ separate integers n add up to make the probability of the unit range of μ centered at μ_0. So that $z = 2{\cdot}846 \times 10^{\mu_0} Z$. Then instead of

$$z = 0{\cdot}0047,\ 0{\cdot}0012,\ 0{\cdot}0002,$$
$$\text{at } \mu_0 = \quad 6, \quad 5, \quad 4,$$

as in Table 6, column 6, we have respectively

$$10^9 Z = 1{\cdot}65, \quad 4{\cdot}2, \quad 7,$$

gradated the other way.

In reply to this objection it may be said that there is an awkward question like that in statistical mechanics. It relates to the importance (alias "weight", alias "*a priori* probability") to be assigned to different states of the system. R. H. Fowler in his great treatise (1936, pp. 9–10) confessed that the generally accepted measure of importance was intuitive. My answer will also have to be intuitive. Which is the more meaningful probability, z or Z? Allow me to illustrate the question by an extreme and abstractly numerical contrast, in which all the important social and geographical features are ignored, except only the number of quarrel-dead. If we could thus abstract, then two quarrels involving severally one and two deaths would seem remarkably different; yet two other quarrels involving severally 1,000,001 and 1,000,002 deaths would seem practically indistinguishable. This belongs with the Weber-Fechner doctrine in psychology. The scale of μ corresponds with our intuitive feelings better than does the scale of n. One of the best

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justifications of intuitive practice is the fact that the intuitive scale of magnitudes for stars was in use for a thousand years before it was explained and improved by photometers and logarithms.

In the next section, however, the range of μ or n is eliminated by attending to the *ratio* of civil to foreign for the same range of μ or n.

8. *A Geographically More Thorough Investigation of the Pacifying Effect Connected with Common Government*

Let a historical interval be chosen between the dates T_1 and T_2; also let the range of magnitude be chosen from μ_1 to μ_2. A technique usual in studies of contingency would then be to ascertain, in that interval and range, the number of pairs a, b, c, d as specified in Table 7.

TABLE 7

Definition of Symbols

	Prior Governments Common	*Prior Governments Separate*	*Totals*
Fought one another . .	a	b	$a + b$
Did not fight one another .	c	d	$c + d$
Totals . . .	$a + c$	$b + d$	$a + b + c + d$

The numbers $a + b$ and a in Table 7 are already available in Table 3; indeed for five separate ranges of magnitude μ. But how are c and d to be obtained? For comparison, c must be the number of pairs of conceivable belligerents who might have fought one another in civil wars, but in fact did not do so. This concept is at first sight bafflingly elusive. Yet without c and d we could not proceed to draw any statistical conclusion about the alleged pacifying effect of common government; so an attempt must be made to catch and tame these elusive concepts. The number c cannot be ascertained from works on history, because insurgents were often not recognized as a group until they had declared themselves to be such by revolting. We are thus compelled to think about groups of people who have never had a collective name, and whose frontiers have never been drawn on any map. In so far as contiguity is important, the problem is geographical; but, in comparison with geography as ordinarily understood, the present problem is much more abstract and statistical. How it can be treated will now be explained.

The skin and body effect for sovereign states.—If we took a political map of, say, Europe, and laid over it a piece of fishing net, we could count the number of strings which separated all those pairs of contiguous meshes which were entirely within the body of sovereign states, also we could count separately the remaining number of strings, which therefore pertain to the frontiers, or skins, of states. The ratio of skin to body could thus be estimated. Next let the experiment be repeated with mosquito net. Its meshes are also hexagons, but much smaller than those of the fishing net. The ratio of skin to body would be found to be much smaller than for the fishing net. The notion, thus crudely illustrated, has been the subject of an elaborate treatment entitled "Mapping by compact cells of equal population". The problem was first re-defined as follows:

The map is required to satisfy the following conditions:

(i) Each cell is to contain the same number, h, of persons.
(ii) At most three cells are to meet at a point.
(iii) No cell is to surround another completely.
(iv) National frontiers are to lie in the edges of cells.
(v) Each cell is to be "homóplatous", that is, about as broad as it is long.

The concept of "homóplaty" was discussed from various points of view, including a psychological experiment, and a theory about minimizing the sum of the squares of cell-edges. For these appropriate new words, the adjective "homóplatous" and the abstract noun "homóplaty", I am indebted to the Professor of Greek in Cambridge, D. S. Robertson, F.B.A., who kindly invented them.

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For such a map, covering the whole globe, it is required to find, as functions of h,

s, the number of cells;
C, the number of cell-edges within nations;
F, the number of cell-edges between nations;
B, the number of cell-edges to the sea, polar ice, or desert.

The problem was attacked by a variety of methods, graphical and argumentative. Euler's theorem on the faces, edges and vertices of polyhedra was adapted to political geography, and it then played a leading part. So did the honeycomb pattern and its conformal representations. The effects of the shape of countries, and of the distribution of population in them, were treated approximately by way of integrals; in particular the alternation between town and country was thus formalized. The lengths of coast-lines had to be studied, and were found to be extremely peculiar. A catalogue was constructed of about 390 territories, arranged in order of population. Maps of homóplatous cells, containing a million persons each, were drawn along all the world's sea coasts and land frontiers. The proper account of this long inquiry is ready in typescript, but unfortunately is not yet published. Its principal outcome however is summarized in Table 8.

TABLE 8

Geographical Facts

Summary of World-total of Cells and Edges at the Middle of A.D. 1910

h	=	10^7	10^6	10^5	10^4
s	=	150	1,652	16,745	168,000
C	=	159	3,373	44,200	483,800
F	=	121	831	3,319	12,680
B	=	122	595	2,510	10,090
C/F	=	1·31	4·06	13·32	38·14

The accuracy of these numbers is a difficult question. They are, however, certainly much better than the author's previous estimates (Richardson, 1950*a*, p. 31).

The contiguous cells of every pair meet along one, and only one, edge. Every edge counted in C or F separates one, and only one, pair of cells. The easiest way to count pairs of contiguous cells is therefore to count the intervening edges. Thus C and F resemble the numbers a, b, c, d in Table 7 in so far as they are all numbers of pairs of contiguous groups of persons. Any cell-edge, between or within nations, is the frontier between the two cells which it separates. Like other frontiers, the edge provides a geographical opportunity for land-fighting. The world-totals C and F measure the total geographical opportunities for civil, and respectively foreign, fighting between contiguous cells each of population h. Thus C/F in Table 8 has a resemblance to $(a + c)/(b + d)$ in the notation of Table 7.

To make this resemblance more like equality, the population h of the cells in Table 8 must somehow be connected with the mean magnitude, $\bar{\mu} = \frac{1}{2}(\mu_1 + \mu_2)$, chosen for Table 7. It is here that the assumption (2) comes in.

Let it be accepted that $\bar{\mu}$ in the historical Table 1 is to be related to h in the geographical Table 8 by the assumption (2) . . . . . (10)

Then C/F will be roughly equal to $(a + c)/(b + d)$. There is, however, a correction for date which needs attention. The year 1910 was chosen because before that date censuses were lacking in too many countries. Better for our purpose than C and F at 1910 would be the time-means $\bar{C}$ and $\bar{F}$ over the 110 years A.D. 1820 to 1945. There is no hope of obtaining $\bar{C}$ and $\bar{F}$ accurately, but some approximations are possible. The two main alterations were the growth of world population W, and the changes of frontiers.

If the density of population had varied everywhere in the same ratio, while all political frontiers had remained fixed, then C would have varied roughly as W, and F roughly as $W^{0.5}$, if the distribution had been smooth. The irregularities of frontiers and of the population-density raise the latter index to about $0{\cdot}5_8$. So C/F varied as $W^{0.42}$. From data-collected by Carr-Saunders

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(1936) by the League of Nations and by Dr. Swaroop (K 11676) I have computed that the mean of $W^{0.42}$ was 0·93 of $W^{0.42}$ at 1910.

On this account $\bar{C}/\bar{F} = 0{\cdot}93(C/F)$ at mid 1910. . . . . (11)

The other chief alteration was in the frontiers. Old atlases (Bartholomew, 1860) or historical atlases (*Cambridge Modern History Atlas*; Muir & Philip, 1929) give one some impression of what happened. They are not adequate, because the populations are not all known. Also the boundaries of less civilized kingdoms in Africa and elsewhere are omitted; that might not so much matter if all the wars between such kingdoms were also omitted from the historical statistics. Both amalgamations and secessions occurred. In Africa many frontiers were formed between new colonies. In Asia old principalities were absorbed into empires. It is difficult to say which tendency predominated. The author abandons the attempt, accepts (11) meantime, but at the end of the argument considers the possibility of error.

The position so far is that, provided the connection (10) is made,

$$(a + c)/(b + d) = \bar{C}/\bar{F}. \quad . \quad . \quad . \quad . \quad . \quad (12)$$

For the purpose of a χ^2-test we need to think about $(a + c)$ separately from $(b + d)$. This can be arranged by replacing the ratio by a pair of simultaneous equations connected by a common parameter τ, thus

$$a + c = \tau\bar{C}, \qquad b + d = \tau\bar{F}. \quad . \quad . \quad . \quad . \quad . \quad (13)$$

The contingency-table 7 is intended to represent some feature of world-society, a feature beyond the control of the investigator. Yet the investigator chooses the historical interval and the range of magnitude, both of which affect a and b. There must be some considerations, akin to "dimensional analysis" in physics, which restrict τ so as to compensate for any irrelevancies introduced by the choice of T_1, T_2, μ_1, μ_2. For definiteness let $T_1 < T_2$ and $\mu_1 < \mu_2$.

The distribution of wars in time has been expressed by the probability λdt that some unspecified war would come to an end in the time-element dt; and λ was found to vary slowly (Richardson, 1945; Moyal, 1949). The geographical opportunities for fighting may suitably be compared with this moderately constant λ. Or, to express the same idea differently, suppose that the investigator, while keeping the mid-date $\frac{1}{2}(T_1 + T_2)$ fixed, were to reduce the interval $(T_2 - T_1)$ from 110 years to 55. Then a and b would be roughly halved. In order that c and d might continue to be comparable with a and b, it is necessary that τ should be proportional to the historical interval.

The variation of the frequency of deadly quarrels with magnitude has also been studied (Richardson, 1941 and 1948*a*). It is more complicated than the distribution in time, because a steep frequency-curve is involved. Nevertheless a similar argument about τ can be made, provided that $\mu_2 - \mu_1$ is small, but not too small.

Therefore τ may be written

$$\tau = \theta(T_2 - T_1)\ (\mu_2 - \mu_1), \quad . \quad . \quad . \quad . \quad . \quad (14)$$

provided $\mu_2 - \mu_1$ is suitably small, where θ does not involve $T_2 - T_1$ nor $\mu_2 - \mu_1$, but is otherwise an unknown coefficient. The investigator makes two other choices, namely the unit of time and the base of the logarithms. Neither of these choices is relevant to the social relations. Neither of them alter a, b, $\bar{C}$, nor $\bar{F}$ in (13); therefore they do not affect τ. Consequently the compensation for their arbitrariness must be made by corresponding alterations in the numerical value of θ, in the usual manner. As in physics, so here, dimensional analysis tells us how coefficients depend on arbitrary choices, but does not fix the numerical coefficients absolutely.

There is, however, some other evidence about θ. The specially drawn maps on which C and F were counted were not unique; they were only samples of all the maps satisfying the conditions (i), (ii), (iii), (iv), (v) for the given cell population h. There was evidence that C and F would be almost the same for any such map. Yet the positions of the cells and the names of their inhabitants could vary a great deal. Therefore:

there is likely to be a numerically large factor in θ . . . . . (15)

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The above discussion of τ and 0 has cleared away various obscurities, but unfortunately has not yielded a definite numerical value for τ. The problem will be resumed on a subsequent page.

The historical facts about fighting in Table 3 can now be compared with the geographical opportunities for fighting in Table 8 by way of the logical scheme in Table 7. The correction (11) is introduced; and j is the uncertain number in equation (2). The comparison is displayed in Table 9.

TABLE 9

Comparison of History with Geography, Years A.D. 1820 *to* 1945 *inclusive*

Ends of Range of Magnitude of the Quarrel as a Whole	*Pairs who Actually Fought*		*Ratio of Civil to Foreign*					
				For Geographical Opportunities $\bar{C}/\bar{F}$				
	a	b	*Actual* a/b	$j=1$	$j=2$	$j=3$	*Least of the* χ^2 *from* (19)	$P(\chi^2)$
$5\pm\frac{1}{2}$	6	3	2	3·78	1·22	0·4	—	—
$4\pm\frac{1}{2}$	10	15	0·67	12·39	3·78	1·22	2·23	0·14
$3\pm\frac{1}{2}$	65	64	1·02	35·47	12·39	3·78	64·0	0·0000

The interim interpretation of Table 9 is made by comparing a/b with $\bar{C}/\bar{F}$ for all the values of j. For magnitudes around 5 it is seen that a/b lies between the extreme values of $\bar{C}/\bar{F}$: that is to say actual fighting was distributed between civil and foreign about in the ratio of their respective geographical opportunities. On the contrary for magnitudes less than 4·5 the actual a/b was less than the geographical $\bar{C}/\bar{F}$. Table 9 suggests therefore that *for magnitudes less than* 4·5 *there must have been some influence which repressed civil fighting relatively to foreign fighting.*

Before we accept this conclusion, let us try to suppose that the apparent contingency has arisen merely by chance, and let us test this supposition in the usual manner by forming, in the notation of Table 7,

$$\chi^2 = \frac{(ad-bc)^2\,(a+b+c+d)}{(a+b)\,(c+d)\,(a+c)\,(b+d)}; \qquad . \quad . \quad . \quad . \quad (16)$$

and by comparing χ^2 with Yule's table of its distribution for one degree of freedom (quoted by Kendall, 1943, pp. 444–5). This standard procedure is here impeded by an unusual difficulty, because c and d have to be found from the two equations (13) which involve an unknown parameter τ. It follows that

$$\chi^2 = \frac{\tau(\bar{C}+\bar{F})\,(a\bar{F}-b\bar{C})^2}{(\tau\bar{C}-a+\tau\bar{F}-b)\,\bar{C}\,\bar{F}\,(a+b)} \qquad . \quad . \quad . \quad . \quad . \quad (17)$$

To make further progress we must know more about τ. The following considerations are decisive. In Table 6 the fraction of the whole time during which any two specified contiguous cells fought one another was denoted by z, and was found to be less than 0·005, when no other cells joined in. This fraction has some resemblance to $(a+b)/(a+b+c+d)$. They are not strictly comparable, because one is a fraction of time, and the other of the number of deadly quarrels in a time-interval. These would be comparable if each fighting had the same duration; but actually the durations have varied from a few days to thirty years. Nevertheless it is conspicuous that sovereign states have usually approached the "dread arbitrament of war" with caution. The fightings that went on at any time were much less numerous than those which were geographically possible. Prospective insurgents have also had reason for caution. It will therefore be assumed that:

In Table 7 the fractions $a/(a+c)$ and $b/(b+d)$ were much nearer to zero than to unity. (18)
This assumption will be referred to as . . . . . .

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In view of (18), the quantity a may be neglected in comparison with $\tau\overline{C}$ and b in comparison with $\tau\overline{F}$. Accordingly (17) simplifies to

$$\chi^2 = \frac{b^2}{(a+b)}\frac{\overline{C}}{\overline{F}}\left\{\frac{a}{b}\frac{\overline{F}}{\overline{C}} - 1\right\}^2, \qquad . \quad . \quad . \quad . \quad (19)$$

from which τ is absent, while $\overline{C}$ and $\overline{F}$ occur only as their ratio. This limiting form of χ^2 may have other applications. I have not noticed it in any textbook.

The values of χ^2 were computed from formula (19) for the three values of j, and the least χ^2 is shown in Table 9, together with the probability $P(\chi^2)$ that a greater χ^2 might have arisen merely by chance. At magnitudes around 4, and for $j = 3$, the conclusion is not significant. But it would be if $j = 2$ were taken, for that gives $\chi^2 = 22$, $P(\chi^2) = 0\,000{,}00$. Here it should be remembered that, according to (2*a*), the uncertain j is more likely to be 2 than 1 or 3; these outliers having been inserted to guard against rash conclusions.

For magnitudes around 3 the attempted explanation by mere chance is utterly incredible. The connection with common government is extremely significant. Now is the time to remember that alterations of frontiers were neglected, and to notice that there is room for a considerable "factor of safety".

The conclusion has already been stated in the initial "Summary and Outlook".

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Differences in Results Obtained by Experienced and Inexperienced Interviewers

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Introduction

1. This paper is a continuation of the report in which Durbin and Stuart* showed that, in a survey in which people were approached in their homes, experienced interviewers of the Government Social Survey and the British Institute of Public Opinion were able to get responses from greater proportions of their respective samples than were the inexperienced interviewers from the London School of Economics.† In this analysis of the responses further features of the interviews are summarized in Sections I to IV, and finally, in Section V, there is the major comparison of the results recorded by the three classes of interviewer. The main conclusion is that the evidence gives no clear ground for assuming that differences in results recorded by investigators of the three participating organizations arose from differing abilities, or that the inexperience of the L.S.E. students led to their recording opinions, preferences or facts significantly different from those recorded by the experienced interviewers of the other organizations.

2. Details of the sample, its drawing with regard to area, sex and age, its allocation to the three questionnaires and the three participating organizations and the proportions of successful contact are given in the paper mentioned above by Stuart and Durbin. Certain features, however, seem of special importance, and should be remembered whilst considering this paper; they are:

(i) The interviewers provided by each of the three participating organizations are treated as if they were homogeneous groups and comparison is only made between groups, never between individuals.

(ii) The interviewers provided by the London School of Economics were volunteers, and were not asked to get as many questionnaire forms completed as were the professional interviewers of the other organizations. Hence, they not only had less general experience of interviewing, but less experience with the three forms used in this investigation. The following table summarizes the position:

	Interviews Sought	*Number of Interviewers used*	*Average per Interviewer*
Goverment Social Survey . . .	504	19	27
Brit. Inst. of Public Opinion . .	504	27	19
London School of Economics . .	504	55	9

(iii) The classification data on all three questionnaires and the remainder of two questionnaires were of the type to which the G.S.S. interviewers were accustomed, whilst the remainder of the other, the questionnaire on tuberculosis, was of the type to which interviewers of the British Institute of Public Opinion were accustomed. The general instructions to interviewers were selected from the G.S.S. interviewer handbook.

(iv) There was no editing of the forms returned by the interviewers in order to correct for obvious omissions and errors.

Section I.—The Interview Situation

3. Day of the week on which interview took place:

The interviewers were free to make interviews whenever it suited their informants and themselves, subject to completing their assigned lists within a specified period. They were encouraged

* *Journal of the Royal Statistical Society*, **114**, Pt. II, 1951.

† The use of the terms "experienced" and "inexperienced" is a convenience. We realize the three groups of interviewers have other characteristics which may be of significance in their achievements as interviewers.

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to make appointments for interview at times convenient to the informants. Each interviewer dealt with all three questionnaires, and, as would be expected, the distribution of interviews according to the day of the week is similar for each questionnaire. Between organizations, however, there were marked differences, B.I.P.O. interviewers spreading their interviews fairly evenly over the week, whilst G.S.S. interviews were concentrated on week-days, especially Tuesday, Wednesday and Thursday, with very few on Saturday, Sunday and Monday. This is summarized in Table 1.

TABLE 1

Day of Week of Interview

(All Questionnaires)

Organization	*% of Interviews on*								*Number of Interviews Recorded*
	Sun.	*Mon.*	*Tues.*	*Wed.*	*Thurs.*	*Fri.*	*Sat.*	*All*	
G.S.S. . . .	—	3	24	26	23	18	6	100	427
B.I.P.O. . . .	10	17	15	14	14	16	14	100	403
L.S.E. . . .	8	14	21	20	15	14	8	100	348
All organizations .	6	11	20	20	17	16	10	100	1,178

The avoidance of the week-end by the G.S.S. is presumably partly associated with the fact that many of their interviewers work for them what is effectively full time and like week-ends off. Even so, it is remarkable how few interviews were on a Monday, though it may be due to their willingness to interview at times to suit respondents and their use of the first call in order to fix such a time. [47 per cent. of their successes were obtained at second calls (Durbin and Stuart, Table 15.] B.I.P.O. employs part-time interviewers, some of whom will prefer to work at week-ends, and their distribution is acceptably a sample from a uniform distribution over the days of the week with a probability of 0·4 of a higher χ^2 value by chance from a uniform distribution. The L.S.E. distribution is not acceptably a sample from a uniform distribution, and the G.S.S. even less so.

4. Persons present at the interview:

The replies of an informant during an interview may be altered or distorted if others, whether of his own family or not, are present; he may seek to impress or to hide information or he may simply be distracted. Any survey attempts to avoid such influences, and the interviewers in this experiment were instructed to make every effort to be alone with their informant during the course of the interview. One might expect that here the expertise of the professional interviewer would show up, but reference to Table 2 reveals the fact that on each survey each type of interviewer got much the same proportion of informants alone. The largest recorded difference is between the B.I.P.O. and the L.S.E. interviewers on the Reading Survey, 68 per cent. against 57 per cent. The standard error of the difference between these two proportions is 6 per cent. and as we are here dealing with the largest out of 9 possible comparisons there is no reason to suppose any real difference.

The proportion interviewed alone, at 55 per cent. in the savings survey was lower than the 62 per cent. of the reading and tuberculosis surveys, although savings might be considered a more confidential matter than either of the other two. The lower proportion is recorded by all three organizations, and in the aggregate the difference of 7 per cent. is about twice the standard error (on samples of 374 and 426). These two factors suggest the difference is significant. The 5 per cent. significance level for the greater of two independent differences is approximately 2·3 times the standard error.

If it is considered that spouse and children are not so objectionable during an interview as adults other than the spouse, it is noted that the G.S.S. shows the most satisfactory result, and compared with the L.S.E. the difference of 5 per cent. is very nearly twice the standard error of the difference. This effect is apparent for all questionnaires combined, but not for the savings questionnaire alone.

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TABLE 2

Persons Present at Interview

Questionnaire	*Organization*	*% of Interviews at which*				*Number of Interviews Recorded*
		Informant Alone	*Spouse Present*	*Other Adults Present*	*Children Present*	
Reading	G.S.S.	63	22	11	18	137
	B.I.P.O.	68	18	15	10	131
	L.S.E.	57	19	18	16	107
	All organizations	62	20	15	15	375
Savings	G.S.S.	57	24	18	13	136
	B.I.P.O.	57	22	16	17	132
	L.S.E.	52	29	18	15	106
	All organizations	55	24	18	15	374
Tuberculosis	G.S.S.	61	24	11	11	151
	B.I.P.O.	63	17	13	13	144
	L.S.E.	63	20	20	15	131
	All organizations	62	20	14	13	426
All questionnaires	G.S.S.	60	23	13	14	424
	B.I.P.O.	62	19	15	13	407
	L.S.E.	57	22	18	15	344
	All organizations	59	22	16	14	1,175

Note.—The totals add to more than 100 because some interviews take place with more than one class of other persons present.

5. Interviewers' assessments of the interviews:

The interviewers were asked to assess the interviews in four classes, as being "above average", "average", "below average", or "very poor". 14 per cent. were recorded as above average in the reading survey, 17 per cent. in the savings survey and 21 per cent. in the tuberculosis survey. Apart from this there is little to notice except the tendency for the G.S.S. interviewers to restrict themselves to the non-committal "average" in 79 per cent. of the interviews compared with 73 per cent. by B.I.P.O. and 61 per cent. by L.S.E.

Section II.—Comparison of the Samples Obtained for the Three Questionnaires

6. As explained by Durbin and Stuart, the samples allotted to each questionnaire were obtained identically. The samples ultimately analysed were modified because some persons refused information. Age and sex were used as controls in the experimental design and no significant modifications appeared as a result of refusals. Other important facts about respondents relate to income, occupation, number of persons in the household and the number of rooms occupied by the household, and the recorded classifications in these respects are summarized in tables 3 to 6 inclusive. For each classification the value of χ^2 was obtained and the resulting probability calculated as if for an independence test on a contingency table.

Table 4 shows the distribution of respondents by occupation when a ninefold classification of occupations is utilized. Here there are differences significant at the 5 per cent. level and attributable to the absence of persons classified as managerial or professional in the savings survey. Table 6 classifies respondents according to the number of rooms occupied by the household to which they belong, and here, too, the differences are substantial though not significant at the 5 per cent. level, there being approximately a 9 per cent. chance of a higher χ^2 arising from chance. Again, the difference arises in the savings survey, which records a smaller proportion of households living in 6 rooms and a higher proportion of households living in 1 or 2 rooms than the other surveys.

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The distributions of respondents by income and by size of household (Tables 3 and 5) both show reasonable agreement, the value of χ^2 on the income classification being considerably increased by the low proportion in the tuberculosis survey who refused to disclose their income or who said they did not know it. The other classification items were similarly tested and show no differences between questionnaires outside the 5 per cent. significance levels, and the results for income and size of household can be considered typical of them.

It is possible that there is a meaningful correlation between the absence of the managerial and professional classes in the savings survey and the deficiency of six-roomed dwellings. It may be that managerial and professional people have a greater tendency to refuse to answer questionnaires about savings than about reading and tuberculosis, whilst their incomes may not now be so different from that of other people that their absence would distort a summary of general income distributions. This, however, is all supposition. The presence of one distribution with significant differences in a group of 9 classification items does not lead one to doubt seriously the validity of the samples as random ones from the same population. It may be worth while, however, when considering the replies to the individual questionnaires to remember that tests showed the reading and tuberculosis samples to be very similar in all respects, whilst there were some differences in the savings sample.

TABLE 3

Income per Week of Respondents by Questionnaires

d.f. 12. P. ·14

Percentages of Respondents

Questionnaire	Nil	*Up to* £3	£3– £5	£5– £7 10*s.*	£7 10*s.* –£10	£10–	*Refused and D.K.*	*Total*	*Number in Sample*
Reading . .	15	19	15	27	10	5	9	100	363
Savings . . .	18	16	18	28	9	4	7	100	371
Tuberculosis . .	19	19	14	32	8	4	4	100	417
All . . .	17	17	16	29	9	5	7	100	1,151

TABLE 4

Occupation of Respondents by Questionnaire

d.f. 12. P. ·04

Percentages of Respondents

Questionnaire	*Managerial and Professional*	*Supervisory*	*Higher Clerical*	*Routine Clerical*	*Skilled Operative*	*Unskilled Operative*	*Housewives*	*Retired*	*Others*	*Total*	*Number in Sample*
Reading .	5	3	4	4	13	10	40	4	17	100	377
Savings .	—	2	3	6	14	11	42	5	17	100	364
Tuberculosis	4	2	2	4	15	15	41	3	14	100	431
All .	3	2	3	5	14	12	41	4	16	100	1,172

TABLE 5

Total Persons in Respondent's Household by Questionnaire

d.f. 12. P. ·5

Percentages of Respondents

Questionnaire	*Number of Persons* 1	2	3	4	5	6	7 *and over*	*Total*	*Number in Sample*
Reading . . .	5	22	28	23	10	7	5	100	375
Savings . . .	7	22	23	26	11	5	6	100	376
Tuberculosis . .	5	20	31	20	10	7	7	100	431
All . . .	6	21	27	23	10	7	6	100	1,182

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TABLE 6

Number of Rooms in Respondent's House by Questionnaire

d.f. 10. P. ·09

Percentages of Respondents

Questionnaire	*Number of Rooms*						*Total*	*Number in Sample*
	1 and 2	3	4	5	6	*7 and over*		
Reading . .	12	27	23	17	17	4	100	375
Savings . . .	16	26	23	18	12	5	100	371
Tuberculosis . .	11	21	24	19	20	5	100	423
All . . .	13	24	23	18	17	5	100	1,169

Later in this paper there is mention again of this classification data when comparing the results obtained by the three groups of interviewers. In this respect also only one item appears with significant differences.

Section III.—Completeness of the Schedules

7. Durbin and Stuart defined a success in making a contact as any case in which the questionnaire was wholly or partially completed. This section compares the performances of interviewers in obtaining complete replies and in recording them. Further, it attempts to measure the efficiency with which they find their way through the forms and record the answers received.

8. There is, unfortunately, no way of telling whether an interviewer has gone counter to his instructions or misrecorded his information if the schedule he returns is internally consistent and consistent with his instructions. Further, by taking a little trouble it is possible for an interviewer to fulfil the above requirements. All that can be done from a study of the forms is to check that there are entries whenever there ought to be entries, and that the entries are not showing inconsistencies which must be due to the interviewer (inconsistencies in replies of respondents are not here considered to be the fault of interviewers). The type of inconsistency which can be measured is when question B has only to be asked if the answer to question A is "Yes", and when after a "No" to question A there is an answer to question B. It is apparent, therefore, that this section measures primarily a certain type of care and mechanical accuracy which may be associated with poor interviewing and recording in other, and more important, respects.

9. Table 7 summarizes the omissions by a concept called the mean omission rate. The number of "omissions" made by an interviewer group on a particular question divided by the number of interviews made by that group and involving that question is the omission rate on that question, and the arithmetic average of these rates for a number of questions is the mean omission rate. Any question for which the interviewer failed to make an entry when there ought to have been one, or where he made an entry which could not be deciphered or where there was an interviewer's inconsistency is counted as an omission.

Further, for purposes of analysis the questions were divided into three types. Classification questions were those asked on all questionnaires about the respondent's social status. The other questions were classified as being either open questions or pre-coded questions. Open questions were those in which the interviewer had to record in words the respondent's answer, and pre-coded questions were those in which he had simply to ring a printed number according to the reply. Open questions require more work on the part of the interviewer, though with pre-coded questions he sometimes has difficulty in fitting individual replies into an appropriate given code.

The table shows that G.S.S. interviewers had fewer omissions than the other two types of interviewers, and this feature was general except in the non-classification questions of the tuberculosis survey. It is improbable that the good record of the G.S.S. in this respect is simply a matter of chance (see Note 1 in the Appendix). The B.I.P.O. interviewers did better in the tuberculosis survey than in the other two surveys, and this may be associated with the fact that the tuberculosis questionnaire was prepared by B.I.P.O., and consisted of a series of short questions requiring short replies of a type to which they were accustomed. The other two questionnaires

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TABLE 7

Mean Omission Rates % by Organization, Questionnaire and Types of Question

Organization	*Reading Questionnaire*				*Savings Questionnaire*				*Tuberculosis Questionnaire*				
	Open Questions	*Pre-Coded Questions*	*Classification Questions*	*All Questions*	*Open Questions*	*Pre-Coded Questions*	*Classification Questions*	*All Questions*	*Open Questions*	*Pre-Coded Questions*	*Classification Questions*	*All Questions*	*All Questions*
G.S.S.	·4	—	·8	·3	·8	·3	·4	·4	1·4	·8	·2	·8	·5
B.I.P.O.	2·5	1·7	1·3	1·8	1·3	2·6	1·8	2·0	1·4	·4	1·0	·9	1·6
L.S.E.	1·5	1·0	2·2	1·5	1·4	2·3	2·4	2·1	1·6	·4	2·5	1·4	1·6
Number of questions	16	31	16	63	11	20	15	46	12	19	15	46	155

were prepared by, and were of a type used by G.S.S. (The questionnaires are printed at the end of Durbin and Stuart's paper.) In the reading and tuberculosis surveys the open questions were omitted more frequently than the pre-coded questions, with the reverse tending to apply with the savings survey. It is possible that omissions tend to occur in questions which involve the interviewers in most work, such as writing down at length what the respondent says. In the savings questionnaire, however, some of the difficult questions asking details about holdings of savings were pre-coded, and this may account for the high omission rates by B.I.P.O. and L.S.E.

The high omission rates by L.S.E. interviewers on the classification questions, asked last in the interview, were very marked.

10. Table 7 obscures the fact that the omissions were highly concentrated on a few questions. Table 8, therefore, shows the questions classified by omission rates. It shows, for instance, that in 118 out of 155 questions analysed the G.S.S. had no omissions at all, and that to only 4 questions did they have omission rates of 5 per cent. or over; both B.I.P.O. and L.S.E. record 68 questions without omissions, whilst the number with rates of 5 per cent. or more were 14 and 13 respectively. In the appendix there is a summary of all the questions in which one or more of the participating organizations record omission rates of 5 per cent. or more. In some questions the omissions seem to be pure oversight by the interviewer or a failure to ring the code for " does not apply ", but in most cases the omissions are apparently failure to get information desired without ringing the code which indicated that the respondent refused information. It was noted, however, that where the omission rate was high the rate for "information refused" was also often high. In the reading survey the omissions tended to be on complex questions with several sub-sections, only some of the sub-sections being completed.

TABLE 8

Frequencies of Questions by Omission Rate and Organization

Organization	*Omission Rate*											*Total Number of Questions*
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%+	
G.S.S.	118	26	5	2	—	1	1	—	—	—	2	155
B.I.P.O.	68	44	14	8	7	6	4	1	1	1	1	155
L.S.E.	68	34	21	11	8	4	5	3	—	—	1	155

Section IV.—The Amount of Information Collected

11. Interviewers may succeed in getting replies from a large proportion of the people in their samples and have few omissions on the forms they have filled in, but may record a disappointing volume of information because respondents refuse to answer some of the questions, or tend to give a high proportion of non-committal replies such as "I don't know" or "I have no preference".

12. Table 9 shows that the proportions of such non-committal replies were almost identical for the three organizations, the percentages given being the mean proportion of non-committal replies taken over all the questions on which a non-committal reply was possible.

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TABLE 9

Mean Proportions of Non-committal Replies as Percentages of Respondents

Organization	*Reading Questionnaire*		*Savings Questionnaire*		*Tuberculosis Questionnaire*		*All Opinion Questions. Non-committal*	*All Other Questions. Non-committal*
	Non-committal	*Sample Number*	*Non-committal*	*Sample Number*	*Non-committal*	*Sample Number*		
G.S.S. . .	9%	137	9%	136	13%	154	12%	9%
B.I.P.O. . .	11%	134	8%	133	11%	144	10%	11%
L.S.E. . .	8%	108	9%	108	10%	134	10%	9%

There were some arbitrary decisions to be made in determining what was a non-committal reply and the following are examples of decisions made:

(i) A reply that a person does not know where to go to have his chest X-rayed was not non-committal.

(ii) Replies such as "Nothing in particular" and "All parts" to the question "What part of the paper do you most like looking at?" were non-committal.

A high proportion of non-committal replies probably means either that interviewers are not pressing their informants sufficiently or, pressing too strongly, are meeting with a kind of passive resistance and are being fobbed off with pretended ignorance or indifference. A low proportion, however, may mean that the interviewers are successfully pressing their informants to give replies which can be put into definite categories, or are forcing the replies into definite categories when the informant's real opinions should not be so classified. This type of forcing seems more likely to occur when asking a person's opinion than in other questions. To test, questions were divided into two types: opinion questions which contained some such phrase as "What do you think . . . ?" or "Would you say . . . ?" and other questions. The last two columns of Table 9 show that the proportions of non-committal replies were similar for each type of question and for each organization.

13. A further method by which an attempt was made to compare the achievements of interviewers was by summaries of the amount of supplementary information they collected. Did they simply provide the minimum, or did they add to the minimum in order to make the position clearer? For open questions it was found too difficult to decide what was extra comment by the interviewer so that this analysis was limited to the pre-coded questions. For pre-coded questions interviewers were told, as is usual, that whenever they were in doubt about their recording of replies they should write down comments, the verbatim reply, or other relevant information. Tables 10 and 11 summarize the proportion of schedules which had such supplementary information. In the reading survey, for example, 31 per cent. of the schedules completed by G.S.S. had one pre-coded question and 23 per cent. had two pre-coded questions containing written comment There is a change of basis between Table 10 and Table 11. In Table 10, which deals with the

TABLE 10

Percentages of Schedules on which Various Numbers of Pre-coded Questions Contained Extra Comments

Questionnaire	*Organization*	*Number of Pre-coded Questions with Comment*											*Mean Number of Commented Questions per Schedule*	*Sample Number*
		0	1	2	3	4	5	6	7	8	9	10 and over / Total		
Reading .	G.S.S.	25	31	23	15	4	2	—	—	—	—	— 100	1·46	138
	B.I.P.O.	31	29	20	14	2	1	2	1	—	—	— 100	1·44	133
	L.S.E.	30	24	21	22	3	—	—	—	—	—	— 100	1·43	108
Tuberculosis	G.S.S.	27	32	20	8	6	4	1	1	1	—	— 100	1·58	154
	B.I.P.O.	15	34	15	11	10	3	3	2	—	2	5 100	2·58	144
	L.S.E.	38	35	14	5	4	2	1	1	—	—	— 100	1·20	134

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reading and tuberculosis surveys, an extra comment was anything which the interviewer may have written against the question other than "Does not apply" or "No answer" where no codes were provided for these. In Table 11, dealing with the savings survey, an attempt was made to judge the value of the comment, and it was only counted if it was judged to add information of value.

B.I.P.O. interviewers made most supplementary comments on the pre-coded questions in both the tuberculosis and the savings surveys, the proportions of their schedules without supplementary comment being significantly smaller than the proportions for the other organizations.

TABLE 11

Percentages of Savings Schedules on which Various Numbers of Pre-coded Questions Contained Supplementary Information

Organization	*Number of Pre-coded Questions with Extra Information*										*Mean Number of such Commented Questions per Schedule*	*Sample Number*
	0	1	2	3	4	5	6	7	8	*Total*		
G.S.S. . .	82	17	1	—	—	—	—	—	—	100	·2	136
B.I.P.O. . .	53	19	15	4	3	4	1	—	1	100	1·0	133
L.S.E. . .	81	9	6	2	1	1	—	—	—	100	·3	108

14. A third comparison of interviewers was an analysis of replies to questions where the answer could involve listing several items. Such questions included the listing of magazines read regularly and summaries of informant's preferences amongst lists of 10 or more classes of reading matter, the listing of policies for life and endowment insurance and respondent's suggestions of the best ways of treating tuberculosis. In five analyses, summarized in the Appendix, there were no significant differences in three of them; in a fourth with a probability of getting greater differences by chance of 9 per cent., the G.S.S. recorded most items of reading preference, whilst in the fifth, with differences significant at the 5 per cent. level, the L.S.E. recorded fewer people without life policies and more with one such policy than the other organizations.

15. The fourth comparison of interviewers relates rather to probable accuracy than to the amount of information. When asking informants how many certificates they held, or how much they had in their post-office savings account, interviewers were asked to encourage respondents to refer to their certificates and savings books. Tables 12 and 13 summarize the information recorded. The total numbers involved are small, as are the proportions who referred to their books. What little evidence there is suggests that the G.S.S. are best and the L.S.E. are worst in this respect.

TABLE 12

Informants with Savings Certificates

Organization	*Number of Informants with Certificates*	*Number of Informants who Referred to Certificates*	*Proportion of Informants Referring to Certificates*
G.S.S. . . .	23	5	22%
B.I.P.O. . . .	35	7	20%
L.S.E. . . .	21	1	5%

TABLE 13

Informants with Post Office Savings Accounts

Organization	*Number of Informants with Savings Accounts*	*Number of Informants who Referred to their Savings Books*	*Proportion of Informants Referring to their Books*
G.S.S. . . .	86	8	9%
B.I.P.O. . . .	64	2	3%
L.S.E. . . .	56	2	4%

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Section V.—Differences in the Replies Recorded

16. Up to now comparisons of interviewer performance have been by means of mechanical tests. Some interviewers returned schedules from a higher proportion of their samples than others, and in consequence it has been recorded that their "success rate" was higher; some had more omissions than others on the schedules they did return; some went to more trouble than others in recording additional information when they thought this would help, and so on. The important factor to determine, however, is whether these differences have been important enough to modify the answers recorded by the different groups of interviewers. Were the people of the type who answered for the G.S.S. but not for the L.S.E. students different in the features being investigated from those of the type who answer for all three organizations? Were they the people with big incomes, of the highest social standing, of the most cultured tastes in reading and with the largest amounts of savings or *vice versa*? Though it has not been found possible to isolate these factors from the other factors which in the aggregate amount to the total interviewer influence, this section attempts to measure the differences which result from all such influences.

17. There are two main ways in which the results recorded by different types of interviewer may differ. Firstly, if the effective sample proportions differ between the groups of interviewers, as in this investigation, there may be a difference in results due entirely to possible bias introduced by the differential response or omission rates. This is called the response bias. Secondly, the interviewers may introduce some bias into the recordings of replies because they stress their questions differently, because they differ slightly in their choice of what to record out of long statements by informants, or because of their personal effect on informants, and such differences in bias may cause differences in the recorded responses even if the different interviewer groups have identical response rates and effective sample numbers. This is called interview bias.

The two effects could operate independently of each other, but normally, when both can be present, it is to be expected that any differences will arise from a combination of the two. Nor is it possible to separate the results of the one from those of the other, for the response bias comes from those differences in response rate and omission rate which are as much functions of the type of interviewer as is interview bias. It is not possible, in fact, to isolate for investigation a group of people and say these are people who respond to G.S.S. interviewers and not to L.S.E. interviewers.

18. It is convenient conceptually to separate response and interview bias, and first some consideration is given to response bias mainly to show that under the conditions of this experiment it would not be clearly detectable even if it were possible to observe it alone. Consider a set of random samples of varying sample number from a binomial population of proportion Π in characteristic A. Let the samples be plotted on a chart such that the X-axis represents the total number in the sample and the Y-axis the number in the sample with characteristic A. Then if $p_1\ p_2 \ldots$ be the proportions of A in sample 1, 2 . . . the points representing each sample will be the points $y_s = p_s x_s$, and we would expect these points to lie around the line $y = \Pi x$; more accurately we would expect 95 per cent. of them to lie between the curves

$$y = \Pi x + 1{\cdot}96\sqrt{\frac{\Pi - \Pi^2}{x}}$$

and

$$y = \Pi x - 1{\cdot}96\sqrt{\frac{\Pi - \Pi^2}{x}}$$

If, as is general, we do not know Π then we must estimate it, and we use as our estimator the combination of all the sample proportions, namely

$$\hat{\Pi}_s = \frac{\Sigma p_s x_s}{\Sigma_s x_s}$$

even though this must in practice combine both types of bias. Now with such a scheme we may test whether there is a differential response bias. For if several effective samples have differing

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sample numbers x_s and sample proportions p_s, we may set up the hypothesis that they are all random samples and test whether the set of $y_s = p_s x_s$ falls within assigned probability limits. If it does so then we may say that the lesser effective samples were random from the same population as the greater. The test will not, however, tell us anything about the response bias of the greatest effective sample, since we have no way of comparing this with a completely achieved sample.

This test can be extended from binomial to multinomial sampling. If we have, say, m samples of differing effective sample numbers from a multinomial population of parameters $\Pi_1, \Pi_2 \cdots \Pi_p$, then we take as our estimators of the Πs the combined sample estimates

$$\hat{\Pi} = \frac{\Sigma p_{sj} n_j}{\Sigma_j n_j}$$

where now we are calling the effective sample number in the jth sample n_j. From these estimates we may calculate

$$\chi^2 = \Sigma_j \Sigma_s (p_{sj} n_j - \hat{\Pi}_s n_j)^2 / \hat{\Pi}_s n_j,$$

and this statistic will be distributed like χ^2 with $(m-1)(r-1)$ *d.f.* where there are m samples and r classes in each sample. This χ^2 measures the variation of the samples about the estimated value of the true proportions, and upon the hypothesis that they are all random samples its distribution is known. If, therefore, the observed value of χ^2 falls within the assigned probability limits, the samples may be accepted as free from differential response bias with the proviso as before that this says nothing of the response bias of the largest sample.

19. Having stated the principles that might be useful in testing response bias, it is now necessary to consider the extent to which the material available might enable it to be measured under favourable circumstances. The sample numbers used in the experimental design were reduced to the smallest numbers consistent with discrimination between response rates and may not be sufficient for other purposes. The greatest difference in effective sample numbers occurs between G.S.S. and L.S.E. in the reading survey, where G.S.S. provided 137 schedules and L.S.E. provided 108. The difference was almost as great for the savings survey where the corresponding numbers were 136 and 108 respectively.

Suppose in the reading survey the L.S.E. recorded that 40 per cent. of their respondents had a specified characteristic, this would imply that it was recorded in 43 schedules. If, further, the 29 who for purposes of this theoretical analysis are assumed to have responded for the G.S.S. but not for the L.S.E. all had this characteristic, then the G.S.S. would record 72 out of their total sample of 137 as having the characteristic, that is, nearly 53 per cent. It is, in fact, most improbable that every one of the sample responding for G.S.S. but not for L.S.E. is of the kind that L.S.E. report as existing less frequently than those without the characteristic, but it shows that the response bias in such circumstances cannot exceed 13 per cent., which is the difference between the 40 per cent. recorded by L.S.E. and the 53 per cent. by G.S.S. The difference expected from random sampling in 5 per cent. of the cases is 12·4 per cent. or more, so the maximum possible response bias where there is a characteristic possessed by 40 per cent. (or 60 per cent.) of the smaller sample is only just significant at the 5 per cent. level. Table 14 summarizes the above, and indicates also the maximum response bias for proportions other than 40 per cent. and compares them with the 5 per cent. significance level of 1·96 times the standard deviation of the difference.

TABLE 14

Maximum Response Bias Compared with 1·96 *Times the Standard Error*

Proportion in smaller sample of 108	50%	40%	30%	20%	10%
Proportion in larger sample of 137*	60·6%	52·7%	44·8%	37·0%	29·1%
Maximum difference due to response bias	10·6%	12·7%	14·8%	17·0%	19·1%
5% significance level (1·96 std. error)	12·5%	12·4%	12·0%	11·0%	9·5%

* Assuming *all* additional responses are of the less frequent type.

This does not necessarily mean that response bias would always be undetected in samples of the size used here unless the proportions were small and the bias improbably large. If the popula-

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tions being effectively sampled by the two organizations did differ (by the response bias), there would also be superimposed on the response bias the ordinary sampling variations. This is because in practice the samples drawn for the different classes of interviewers are different samples. The ordinary sampling variations would be as likely to increase as to decrease the response bias, and in some cases may make the response bias appear to be significant.

There is another point to bear in mind. The argument and the table above are worked on the basis of the numbers in specific questionnaires. For the classification data, which were the same for all three questionnaires, the numbers in the effective samples are increased three-fold, the maximum differences possible as a result of response bias remain about the same, but the standard error of the difference is nearly halved, so that response bias would be more likely to appear as a significant difference.

20. The effective sample sizes are given in Table 15. With a 100 per cent. response rate each of the nine cells would have consisted of an effective sample of 168.

TABLE 15

Effective Schedules in the Samples Analysed

	Reading	*Savings*	*Tuberculosis*
G.S.S.	137	136	154
B.I.P.O. . . .	134	133	144
L.S.E.	108	108	134

21. The fact that the sample sizes are too small to distinguish response bias easily in much of the material is of reduced importance if it is remembered that in practice response bias is indistinguishable from interview bias. Further, in comparing and considering any results one is primarily concerned with the accuracy, not with the cause of any inaccuracy, whilst even if the cause could be shown as response bias one could not seek to obtain better results by rejecting a specific group of interviewers because their response bias was high and retaining them because their interview bias was low, though one might do something by training.

It is not possible to fix maximum limits to interview bias similar in character to those fixed for response bias, for the only limit is if every respondent for one class of interviewer was classified as being of one type and that the least common type in the population. If there is an interview bias it might tend either to neutralize or to augment response bias. It seems likely that if any significant aggregate bias is revealed it will arise when both response bias and interview bias are in the same direction.

22. The significance test used to determine whether the distributions of answers to a question given by the three organizations showed more than the random fluctuations of samples from the same population is the χ^2 test referred to above. That is, the test is whether three samples of the particular sizes of the effective samples give a χ^2 in excess of that expected had they been random samples of those particular sizes from a multinomial population with the mean estimates of the three samples as parameters. If the distributions of replies be set out in a table where each row represents the distribution for one of the organizations, this test is the same as a test for the distributions over columns to be independent of row, as clearly it should be. If the value of χ^2 thus calculated be in excess of the critical value chosen, then these samples cannot be considered as independent random samples from the same population. Since the original samples as drawn were independent, then cases of significant difference lead to a presumption that the differences are due to the influences of the interviewers with certain qualifications. The first qualification is that the number of results tested at over one hundred is itself quite substantial, and if they could be considered as completely independent samples a number of them would be expected to record significant differences even if they were really only chance variations from the same population. The second qualification is that the answers were not independent, for the sequence of questions sometimes led to series of correlated answers. Such correlated answers might lead to a series with good agreement between interviewer classes, or equally to a series with bad agreement.

22. The χ^2 test has been made on 119 distributions of answers. In the classification data the answers have been summed over all three questionnaires, thus obtaining the advantages of the greater sample sizes. Table 16 summarizes the distribution of the probabilities of getting higher values of χ^2 by chance when sampling from the same population.

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TABLE 16

Probabilities of Getting Greater Differences Between Interviewer Groups by Chance

Value of P (Probability of Greater χ^2 in Independence Test)		*Number of Answers*	
0·0–0·1		20	
0·1–0·2		21	
0·2–0·3		12	
0·3–0·4		16	
0·4–0·5		10	
———	0·0–0·5	—	79
0·5–0·6		9	
0·6–0·7		8	
0·7–0·8		9	
0·8–0·9		10	
0·9–1·0		4	
———	0·5–1·0	—	40
Number of answers tested			119

Had the 119 distributions been independent of each other, the above table could legitimately have been tested against an expected uniform cell value of one-tenth of 119; or better still, the cumulative distribution of the probabilities tested against a rectangular distribution. On such a test the distribution would have been unacceptable as a random sample.

The next eleven paragraphs (23 to 33) deal with the 20 answers with probabilities of less than 10 per cent. in an attempt to display some significant features of the results obtained by the different interviewers. These 20 questions are distributed between the questionnaires as indicated in the following table (Table 17).

TABLE 17

Frequencies of Questions Giving χ^2 Probabilities of Less than 10%

Survey	*Number of Questions*		*Proportion with—*
	$P < 10\%$	*Total*	*$P < 10\%$*
Reading	11	46	24%
Savings	4	35	11%
Tuberculosis	4	29	14%
Classification questions . . .	1	9	11%
	20	119	17%

The big differences are relatively and absolutely most frequent in the reading survey, largely associated with differences in the complex first three questions and their sub-sections. Apart from this the proportion "significant at the 10 per cent. level" does not appear to be too large to have resulted from chance.

The Twenty Replies with Probabilities Under 10 per cent.

23. For these 20 questions the summaries of the replies are given below, grouped by the questionnaires from which they came with the classification questions in a final group together. The figure of 10 per cent. has been chosen as an arbitrary upper limit for low probabilities rather than 5 per cent., partly in view of the smallness of the size of these samples and partly in order to have a more extended opportunity of examining the data for evidence of any persistent bias effect from the interviewers.

24. *Reading Questionnaire*

On the tests of the distributions of replies to this questionnaire there were 11 questions giving χ^2s with a P less than 10 per cent. Six of these came from the 18 sub-sections of Questions 1, 2 and 3 which dealt with newspaper readership. The particular sub-sections giving these low probabilities were 1*(d)*, 2*(f)*, 3*(a)*, 3*(b)*, 3*(c)* and 3*(f)*. An outline of the schematic arrange-

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ment of these three questions has been given in the Appendix to Section 3 dealing with omissions. Question 1 referred to daily, Question 2 to Sunday and Question 3 to evening papers. Sections *a*, *b*, *c* referred to papers read the previous day (or in the case of Q. 1 and 3 for an interview on a Monday to the paper read the preceding Saturday) or last Sunday. Sections *d*, *e*, *f* referred to papers read regularly.

Sections *a* and *d* asked the name or names of the papers read, and Section *f* the part or parts of the paper preferred, and involved multiple answers in each case. There would clearly be a correlation between the papers which respondents read in combination, and similarly a correlation between the parts jointly preferred and therefore the χ^2 tests made on these sections are illegitimate in view of the resulting loss of independence of the cell frequencies. It will be necessary therefore to consider in detail the greater part of these questions. Considerations of space preclude the reproduction of tables showing the relative frequencies of all replies, and an abstract of only those replies which differed between organizations will be given.

Table 18 shows the proportionate frequencies of stated readership of certain daily papers read yesterday and regularly, and the corresponding figures for the first paper so mentioned.

TABLE 18

Readership of Certain Daily Papers

Newspaper and Organization	*Read Yesterday*		*Read Regularly*	
	Mentioned at all	*Mentioned first*	*Mentioned at all*	*Mentioned first*
Express:	%	%	%	%
G.S.S. . . .	23	15	23	16
B.I.P.O. . . .	13	8	13	10
L.S.E. . . .	17	11	15	10
Mail:				
G.S.S. . . .	5	3	3	3
B.I.P.O. . . .	10	6	10	6
L.S.E. . . .	7	8	6	5
Graphic:				
G.S.S. . . .	5	4	4	2
B.I.P.O. . . .	10	5	10	6
L.S.E. . . .	4	1	4	1

Sample Numbers: G.S.S. 137, B.I.P.O. 132, L.S.E. 108.

25. These are the largest differences shown in the readership of the daily papers, and none of them is significant at a 5 per cent. level when considered as the largest of two independent differences. No other differences arise on Question 1 *a*, *b*, *c*, *d*, *e*, and we may take the daily paper results as being acceptably within sampling fluctuations.

26. A similar analysis on the readership of Sunday papers in Question 2 shows no differences between organizations. On Q. 3, however, Table 19 shows differences greater than the 5 per cent. point between the proportions marked *.

TABLE 19

Readership of Certain Evening Papers

	Organization	*Read Yesterday*	*Read Regularly*
		%	%
None . . .	G.S.S.	35*	28*
	B.I.P.O.	23*	16*
	L.S.E.	18*	16*

	Read Yesterday		*Read Regularly*	
	Mentioned at all	*Mentioned first*	*Mentioned at all*	*Mentioned first*
Star:	%	%	%	%
G.S.S. . .	30*	27*	36*	30
B.I.P.O. . .	48*	40*	45*	39
L.S.E. . .	45*	37*	43*	35

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The sample numbers vary slightly with the sections concerned here owing to the omissions by B.I.P.O. and L.S.E. already noticed [Appendix 2(i)] .The maximum response biases corresponding to the significant L.S.E.-G.S.S. differences shown in each column above, reading from left to right and downwards, are as follows:

Maximum response bias . . .	18	18	16	16
Observed difference . . .	17	12	15	10

so that it is possible that these differences are due to response bias rather than interview bias; and to the effect of the lesser L.S.E. response rate rather than the higher L.S.E. omission rate. However, it is doubtful whether this is correct in view of the fact that certain of the B.I.P.O.-G.S.S. differences were greater than the L.S.E.-G.S.S. differences, and that in all the comparisons of Table 19 B.I.P.O.'s proportion lay closer to L.S.E.'s than to G.S.S.'s; whereas the sample numbers, ignoring omissions, were G.S.S. 137, B.I.P.O. 132, L.S.E. 108, and when omissions on the papers read regularly are taken into account we have G.S.S. 137, B.I.P.O. 125, L.S.E. 108 on 3*d*, and G.S.S. 137, B.I.P.O. 121, L.S.E. 106 on 3*e*. There would thus seem to be no response bias between B.I.P.O. and L.S.E., and greater observed differences than could be accounted for by response bias between B.I.P.O. and G.S.S. Since the omissions were confined to B.I.P.O. and L.S.E. and it is these two together who differ from G.S.S. by more than these omissions could account for, or in the case of B.I.P.O. than their difference in non-contacts could account for, we may attribute the observed differences more to interview than to response bias. This conclusion, however, is not supported by the differences on the *f* sections of these three questions, which we discuss next. There is also a possibility that the lack of G.S.S. interviews on Sundays, and Mondays, both of which would be concerned with Saturday's papers, is a factor.

27. Questions 1*c*, 2*c*, 3*c*, asking in general terms how much of yesterday's paper the respondent read, showed no differences between the organizations. Questions 1*f*, 2*f*, 3*f*, however, which asked what particular parts of the paper the respondent preferred, show disagreement between organizations. Table 20 shows the proportion recorded by each organization of preferences for those items with significant differences, making five items out of nine specific items and two residual codes. The table deals with all three types of paper, daily, Sunday and evening.

TABLE 20

Preferences on Certain Items in Daily, Sunday and Evening Papers Read Regularly

Organization	*Nothing*			*Letters*			*Puzzles*			*Sport*			*Other*		
	D. %	*S.* %	*E.* %	*D.* %	*S.* %	*E.* %	*D.* %	*S.* %	*E.* %	*D.* %	*S.* %	*E.* %	*D.* %	*S.* %	*E.* %
G.S.S. . .	9	17*	11	20	6*	3	1	3*	1*	19*	26	13*	28*	24*	16
B.I.P.O. . .	2	8*	5	24	21*	8	6	8*	6*	23*	30	25*	20*	20*	11
L.S.E. . .	5	10*	7	22	14*	11	7	13*	11*	32*	30	29*	10*	31*	11

D = Daily Papers. S = Sunday Papers. E = Evening Papers.

On daily papers there is a difference between L.S.E. and G.S.S. on "Sport" and "Other", L.S.E. showing a greater "Sport" and G.S.S. a greater "Other" proportion. But this is the only simple difference shown, for on Sunday and evening papers the three organizations show a jumble of differences. If we rank the proportions shown in order of size among organizations we get a slightly clearer picture and this has been done in Table 21.

TABLE 21

Rankings of Proportions in Table 18

Organization	*Nothing*			*Letters*			*Puzzles*			*Sport*			*Other*		
	D.	*S.*	*E.*	*D.*	*S.*	*E.*	*D.*	*S.*	*E.*	*D.*	*S.*	*E.*	*D.*	*S.*	*E.*
G.S.S. . .	1	1	1	3	3	3	3	3	3	3	3	3	1	2	1
B.I.P.O. . .	3	3	3	1	1	2	2	2	2	2	1½	2	2	3	2½
L.S.E. . .	2	2	2	2	2	1	1	1	1	1	1½	1	3	1	2½

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It is apparent that there are only two cases in which the order has been altered from that shown on daily papers, namely, "Letters" on evening papers and "Other" on Sunday papers. The size of the changeover on "Letters" is small; on "Other", however, L.S.E. rises from a 10 per cent. proportion to a 31 per cent. proportion. We can say therefore that the differences between the organizations are substantially the same on all types of paper with the exception that in the "Other" category of Sunday papers L.S.E. takes the place of G.S.S. in showing the highest proportion while the other two organizations remain stable.

Although the orders of the sizes of preference remain practically constant from daily to Sunday and evening papers, the sizes of the differences between organization become greater and more of them exceed the sampling limits. It is on Questions 2 and 3, especially the *f* sections, that B.I.P.O. and L.S.E. showed omissions, and since one would expect any interview bias on these *f* sections to make itself felt in the answers to Questions 1*f* as well as 2*f* and 3*f*, there is here an indication that response bias has affected the returns of B.I.P.O. and L.S.E. through their omissions.

28. Of this first page of the Reading Questionnaire we can say that differences appeared between the three interviewer groups; but to define their nature shortly is impossible. On the readership of daily papers the organizations returned homogeneous recordings; but on Sunday and evening papers their results in many cases cannot be supposed to have arisen from random samples from the same population; nor does one organization deviate consistently from the other two which agree, but all three differ. In particular, we can note no continued difference between the distributions of replies shown by the inexperienced interviewers on the one hand and those shown by the two groups of experienced interviewers on the other. In spite of this somewhat equivocal result it is of advantage to have recorded the analysis of this part of the questionnaire in some detail, because the pattern or lack of pattern which emerges is typical of the remainder of the material and we shall be able to deal with the rest more summarily, noting such differences as occur but without attempting each time to fit them into a pattern which we at least were not able to find from the figures given below.

29. Summaries of the other five answers of low probability on the Reading questionnaire are given in Tables 22 to 26.

The last four of these were contingent questions; Questions 11 and 23 were addressed only to those respondents who had previously said they read books, and Questions 8 and 20 only to those who, while admitting to reading books, were not currently reading one or whose current book was "Not particularly good". The numbers involved in these questions are small.

TABLE 22

Question 4: *Do you Read any of the Local Newspapers Regularly*?

Organization	*Replies as Percentages of Total*		*Total*	*Sample Number*
	Yes	*No*		
G.S.S. . . .	41	59	100	137
B.I.P.O. . . .	55	45	100	133
L.S.E. . . .	48	52	100	107

TABLE 23

Question 11: *Are you Reading any Book of any Kind at the Moment*?

Organization	*Replies as Percentages of Total*		*Total*	*Sample Number*
	Yes	*No*		
G.S.S. . . .	60	40	100	73
B.I.P.O. . . .	44	56	100	81
L.S.E. . . .	44	56	100	56

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TABLE 24

Question 18: *Can you Tell me the Name of the Last Good Book you Read?*

Organization	*Replies as Percentages of Total*		*Total*	*Sample Number*
	"Don't Know"	*Names Book*		
G.S.S. . . .	33	67	100	31
B.I.P.O. . . .	50	50	100	52
L.S.E. . . .	25	75	100	36

TABLE 25

Question 20: *What was It About?*

Organization	*Replies as Percentages of Total*		*Total*	*Sample Number*
	Fiction	*Other*		
G.S.S. . . .	77	23	100	31
B.I.P.O. . . .	56	44	100	52
L.S.E. . . .	71	29	100	36

TABLE 26

Question 23: *During the Past Week how many Hours would you Say you had Spent Reading Books?*

Organization	*Replies as Percentages of Total*				*Total*	*Sample Number*
	No time at all	*Up to 2 hours*	*2–7 hours*	*7 hours and over*		
G.S.S. . . .	35	10	25	30	100	72
B.I.P.O. . . .	50	12	24	12	100	81
L.S.E. . . .	40	23	20	17	100	56

30. There remain two points relating to the distributions of replies on the Reading Questionnaire, neither of which argues for any systematic difference between interviewer groups. Firstly, a comparison was made between the replies to Q. 24 and the replies to Q. 6, which was an identical question asking for the time spent in reading newspapers and magazines. The purpose of the comparison was to discover whether or not there was any similarity in pattern in the deviations of the different organizations' various reply proportions from their means over organization; no such similarity was discernible. Secondly, it is worth noting that while the G.S.S. showed a higher number of separate items mentioned in answer to Q. 26, 27, 28, there was no effective difference as a result between the G.S.S. distribution of preferences and those of the other two organizations on any of these questions.

Savings Questionnaire

31. There were four questions out of 35 tested on this questionnaire which gave χ^2 probability of less than 10 per cent. Tables 27 to 30 give summaries of replies recorded.

TABLE 27

Question 10(b) (*ii*): *Have you Bought any Savings Certificates for Yourself since the Beginning of* 1949?

Organization	*Replies as Percentages of Total*		*Total*	*Sample Number*
	Yes	*No*		
G.S.S. . . .	10	90	100	65
B.I.P.O. . . .	22	78	100	68
L.S.E. . . .	22	78	100	44

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TABLE 28

Question 12: *Have You an Account Open at the P.O.S.B.?*

Organization	*Replies as Percentages of Total*		*Total*	*Sample Number*
	Yes	*No*		
G.S.S. . . .	64	36	100	134
B.I.P.O. . . .	49	51	100	130
L.S.E. . . .	54	46	100	105

TABLE 29

Question 14: *When did you Last Put Anything into your Post Office Savings Account?*

Organization	*Replies as Percentages of Total*							*Total*	*Sample Number*
	Before 1939	1939–1945	1946–1948	1949	1950	*Refused*	*Vague*		
G.S.S. . .	—	10	30	11	32	2	15	100	86
B.I.P.O. . .	2	4	11	10	33	4	36	100	64
L.S.E. . .	7	9	24	17	19	7	17	100	56

TABLE 30

Question 19: *Expenditures in Pounds within the Last Year on Clothes, Furniture and Setting up Home*

Organization	*Replies as Percentages of Total*						*Total*	*Sample Number*
	Nil	£1–9	£10–19	£20–49	£50–99	£100–		
G.S.S. . . .	57	15	7	13	4	5	100	136
B.I.P.O. . . .	55	15	7	15	9	1	100	133
L.S.E. . . .	47	11	19	13	7	2	100	108

Answers to Question 19 involved recording any special expenditure, and these expenditures were classified into four types of which the above is only one. None of the other three classes of expenditure showed any significant differences.

Tuberculosis Questionnaire

32. In this questionnaire four out of 29 distributions tested gave probabilities of less than 10 per cent. The replies recorded are summarized in Tables 31–36.

TABLE 31

Question 5c: *Do you Think that Not Having Enough Rest can Cause T.B.?*

Organization	*Replies as Percentages of Total*			*Total*	*Number of Replies Recorded*
	Yes	*No*	*Don't Know*		
G.S.S. . . .	57	30	13	100	152
B.I.P.O. . . .	57	25	18	100	142
L.S.E. . . .	64	29	7	100	133

The difference causing the low probability is the lesser proportion of "Don't knows" in the L.S.E. returns, the consequent addition to the "Yes" and "No" categories being split proportionately. Questions 5(*a*) and 5(*b*), which were similar questions concerning bad housing and food as causes of T.B., show no such difference, but in both these cases all the "Don't know" proportions are much smaller.

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TABLE 32

Question 10b: *Do you Think T.B. is Curable?*

Organization	*Replies as Percentages of Total*				*Total*	*Sample Number*
	Yes	*No*	*Yes, if . . .*	*"Don't Know"*		
G.S.S. . . .	28	12	17	43	100	154
B.I.P.O. . . .	54	19	13	14	100	142
L.S.E. . . .	38	28	14	20	100	134

There are very marked differences between the interviewer groups here, with B.I.P.O. showing a high proportion of "Yes" answers and a fairly low proportion of "Don't knows", the G.S.S. showing a fairly low proportion of "Yes's" and a high proportion of "Don't knows"; the L.S.E. group lies between the other two on the "Don't know" and "Yes" answers but shows a higher "No" proportion. The same pattern is reproduced on both questions 10*a* and 11 asking if the disease is preventable and if it is catching, but in far less marked a fashion. There would seem to be an indication here of a fairly strong tendency by B.I.P.O. to get "Yes" answers at the expense of "Don't knows", but no line of division between the experienced and inexperienced interviewers. We have, however, already seen that there is no difference between the "Don't know" proportions shown by the three types of interviewer on the questionnaire as a whole, and the same method used on the opinion questions with possible "Yes", "No", "Don't know" answers shows the mean proportion answering "Yes" over all such questions in the Tuberculosis schedule to be—

		Sample Number
G.S.S. . . .	62·8%	154
B.I.P.O. . . .	68·2%	144
L.S.E. . . .	65·0%	134

which are well within 5 per cent. sampling limits of each other. Further, in 11 cases of such questions the highest "Yes" proportion is shown 3 times by G.S.S., 5 times by B.I.P.O. and 3 times by L.S.E. It appears, therefore, that the propensity of B.I.P.O. to get a greater proportion of "Yes" answers at the expense of the "Don't knows", which is marked in the small group Questions 10*a*, *b* and 11, does not persist outside this group.

TABLE 33

Question 14(d): *Would you have any Idea Where to Go to have your Chest X-rayed?*

Organization	*Replies as Percentage of Total*				*Total*	*Sample Number*
	Yes, no place named	*Yes, at Doctor's*	*Yes, other place*	*No*		
G.S.S. . . .	8	14	64	14	100	146
B.I.P.O. . . .	16	10	59	15	100	142
L.S.E. . . .	15	5	60	20	100	132

There are certain differences in the first two categories and in the "No" category none of which are significant by themselves. This question was omitted by the interviewer on 8 G.S.S. schedules, 2 B.I.P.O. schedules and 2 L.S.E. schedules. There is no immediately apparent reason for the omissions; the question was not a difficult one nor was it contingent upon any previous reply. There are in fact no fixed places where a person can have an X-ray upon his own application, and it is suggested that the question was in a real sense confusing to the informants, and that this confusion is reflected both in the omission rates and in the differences between the interviewers, recordings of replies; L.S.E. possibly recording such replies as "I suppose at the Doctor's" as straight "No's" while the other two organizations recorded them verbatim. This is, however, mere speculation.

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TABLE 34

Question 18: *Do you Think that there are or are not Sufficient Hospitals and Sanatoria Available for T.B. Patients?*

Replies as Percentages of Total

Organization	*Are*	*Are Not*	*Qualified Answer*	*"Don't Know"*	*Total*	*Sample Number*
G.S.S. . . .	17	66	3	14	100	153
B.I.P.O. . . .	8	60	5	27	100	144
L.S.E. . . .	14	65	4	17	100	134

Here we have the opposite position from that of Question 10(*b*). B.I.P.O. and G.S.S. differ in that B.I.P.O. shows less "Ares" and more qualified answers and "Don't knows", with L.S.E. showing results between the other two organizations throughout.

Classification Data

33. The analysis of the classification data seems to be of particular importance because larger samples are involved than with the other questions. If the failure to distinguish clearly any differing results achieved by the participating organizations is due to the smallness of the samples something might show up in the classification. The tests were carried out with respect to nine questions; eight of them seemed clearly to arise from chance variations as they all had probabilities greater than 0·3 of arising from chance. Included in the eight is the question about income. The one classification question which gave significant differences was that seeking information about the type of dwelling occupied by the household of which the respondent was a member. Here the difference seems clearly to have arisen because of the tendency for G.S.S. to classify some households as occupying part of a house where B.I.P.O. or L.S.E. classify them as occupying a self-contained flat or whole dwelling. This suggests there ought to have been more investigation by some interviewers to make certain of the extent to which the household concerned was occupying the dwelling, and we have little doubt that the results recorded by G.S.S., operating with their type of schedule and instructions, are better than those of the other organizations.

TABLE 35

Dwellings Occupied by Respondents

Percentage of Respondents Living in—

Organization	*Detached House*	*Semi-Detached House*	*Terrace House*	*S/C Flat*	*Part of House*	*Other*	*Total*	*Sample Number*
G.S.S. . .	3	9	32	26	27	3	100	427
B.I.P.O. . .	8	11	32	29	19	1	100	409
L.S.E. . .	3	11	37	29	18	2	100	350

d.f. 8. P. = ·02.

34. A remarkable feature of this survey is the way apparent differences have been reduced when the distribution of characteristics has been calculated over the effective replies by omitting such answers as "Don't know", "Refusal" and "Not recorded". This is strikingly illustrated in the question about earnings in the savings survey. The χ^2 test calculated over all the schedules analysed shows differences which were just significant at the 5 per cent. level. Omitting the ineffective replies and also those who recorded they had no income the distributions were very closely comparable when, for purposes of calculation of χ^2, all incomes over £7 10*s.* a week were combined. (This seemed desirable in view of the small numbers involved with over £10 a week.)

Here both B.I.P.O. and L.S.E. lost 13 per cent. of their contacts through refusals, ignorance or omission, so that though G.S.S. had an effective sample of 80 per cent. of their original 168 possible contacts, B.I.P.O. had 69 per cent. and L.S.E. only 56 per cent.

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TABLE 36

Income per Week, Less Deductions Plus Bonuses

Organization	*Nil*	*Up to £3*	*£3–£5*	*£5–£7½*	*£7½–£10*	*£10–£20*	*Over £20*	*Don't know*	*Refusal*	*Not recorded*	*All*
G.S.S. . .	18	20	18	29	7	6	1	—	1	—	100
B.I.P.O. . .	18	13	17	26	11	2	—	2	10	1	100
L.S.E. . . .	18	13	19	27	8	3	—	2	6	5	100

d.f. 10. P. = ·04.

TABLE 37

Income per Week of those Recording Income

Organization	*Up to £3*	*£3–£5*	*£5–£7½*	*£7½–£10*	*£10–£20*	*Over £20*	*All*	*Sample Number*
G.S.S. . . .	25	22	36	8	7	2	100	135
B.I.P.O. . . .	20	24	37	16	3	—	100	116
L.S.E. . . .	19	27	39	12	4	—	100	94

d.f. 6. P. = ·80.

35. An analysis has been made to find out the type of question upon which differences between interviewers arose by classifying questions as requesting information about opinions, or facts, or preferences. Table 38 shows that the differences in the answers recorded by the three classes of interviewers are most marked in the factual questions.

TABLE 38

Proportions of Questions Giving χ^2 Probabilities of Less than 10%

Type of Question	*Number of Questions* $P < 10\%$	*Number of Questions* *Total*	*Proportion with* $P < 10\%$
Opinion	3	36	8%
Factual	15	67	22%
Preference	2	16	12%
	20	119	17%

36. Another analysis involved a classification of the probabilities. Where the probabilities exceeded 10 per cent. it was said that the results of all the organizations were in agreement. The remaining 20 results with probabilities of less than 10 per cent. were examined to see where the significant differences appeared to arise, though the full series of $\binom{3}{2}$ χ^2 tests required for rigorous testing on each of the distributions were not carried out. From this examination it appeared that the disagreement arose from one organization with the other two agreeing in nine of the twenty answers, each organization being in disagreement three times. In a further six examples the organizations showing the greatest disagreements were significantly different whilst the other organization with results in between was not significantly different from either but not markedly closer to one than the other. In the remaining five samples there were significant differences between all three organizations.

If there were marked differences between the L.S.E. inexperienced interviewers and the experienced professionals we would have expected:

(*a*) A lower proportion than 83 per cent. of the answers with all organizations in agreement.

(*b*) Where two agree and one disagrees that in most cases the disagreeing organization would be the L.S.E. instead of each organization disagreeing the same number of times.

(*c*) Where two organizations disagree with one lying between that the one between would rarely be the L.S.E. instead of it most frequently being the L.S.E.

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TABLE 39

Analysis of Agreements and Disagreements between Interviewer Groups in Recording Answers

		Number of Questions
Answers with—		
1. All three organizations in agreement		99
2. Two organizations agree, one disagrees:		
(*a*) G.S.S. disagrees	3	
(*b*) B.I.P.O. disagrees	3	
(*c*) L.S.E. disagrees	3	
	—	9
3. Two organizations disagree; the other lying between does not disagree significantly from either:		
(*a*) G.S.S. between	0	
(*b*) B.I.P.O. between	1	
(*c*) L.S.E. between	5	
	—	6
4. All three organizations disagree		5
Total		119

The table therefore shows in summary form what we consider to be the chief conclusion to be drawn from this investigation of the replies recorded, namely that they give no ground for supposing that any of the differences in the recorded answers depended on the use of students from the L.S.E. for one of the interviewer groups and experienced professional interviewers for the other two groups.

We have only been able to estimate whether the groups of interviewers were in agreement with one another in their recorded answers, we do not know the correct answers and realize that answers not consistent with the average recorded may not be wrong. Further the L.S.E. students, able to undertake a single investigation and get replies consistent with replies obtained by professional interviewers, may not make satisfactory interviewers if they have to do it frequently.

Appendix

Note 1.—(i) Differences in the rates in Table 7 are not strictly comparable by means of a standard error significance test since they are means of the rates on separate questions which are far from independent. However, the three questionnaire samples and the three organizations samples being mutually independent, it is possible to base certain conclusions on the persistence of differences over these samples. If we assume that the true rates are equal in each questionnaire as between organizations, then all *orders* of sample rates are equally probable. On three distinct questionnaires with three rates on each the possible different combinations of different orderings of rates is (number of ways of ordering 3 things) $^3 = 6^3$. The number of ways in which the greatest number of times of any organization appearing first is once, twice, three times, are 6.2^3, $6.\binom{3}{2}.2^3$, 3.2^3 and the corresponding probabilities ·2, ·6, ·1. The chance, therefore, that any one of the three organizations should show the lowest omission rate in every questionnaire sample is only ·1 if the rates are really equal. We do not consider this a high probability, and we infer that the omission rates are not really equal and that G.S.S. interviewers are less prone to omissions than the other two types of interviewer. Again, the rates shown by B.I.P.O. are lower on each type of question in the Tuberculosis questionnaire than the corresponding rates for the Savings or Reading questionnaires, and the rates shown by the G.S.S. on open and pre-coded questions are higher for the Tuberculosis questionnaire than the corresponding rates for the Reading and Savings questionnaire. Finally the rates on open questions are in every case higher than the rates on pre-coded questions. No probability measures can be applied in these cases since the sub-groups of pre-coded, open and classification cannot be considered as independent, and this lack of independence seriously weakens any conclusions drawn.

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The rates of the L.S.E. students are not, however, of any very clear pattern; higher than the Social Survey throughout but in two cases, the reading questions, lower than the B.I.P.O. interviewers' rates.

Note 2.—Summary of Questions with Omission Rates over 5 per cent.

(i) In Table A are shown details of the rates on all questions in which any organization's omission rate was 5 per cent. or higher. It is worth while considering these questions separately, since it is they which are responsible for all the differences in Table 7 except the uniformly lower rate of the G.S.S.

TABLE A

Omission Rates % by Organizations on the Questions with Most Omissions

	Organization	*Question Number*					*CVIII Income*	*CXII Education*	*Sample Number*
		2f	*3d*	*3e*	*3f*	8			
Reading	G.S.S.	—	—	—	—	—	1	6	137
	B.I.P.O.	4	7	9	5	7	8	5	134
	L.S.E.	7	—	1	1	1	4	7	108

	Organization	*Question Number*					*CV Marital Status*	*CV Age*	*CVIII Income*	*Sample Number*
		7a	15	16	17	18				
Savings	G.S.S.	—	1	1	—	1	—	—	—	136
	B.I.P.O.	27	4	2	5	6	5	6	1	133
	L.S.E.	19	6	6	4	6	5	7	5	108

	Organization	*Question Number*			*CVIII Income*	*Sample Number*
		8a	*8b*	*14d*		
Tuberculosis	G.S.S.	11	11	5	—	154
	B.I.P.O.	3	6	1	5	144
	L.S.E.	4	4	1	6	134

(ii) Taking first the Reading survey, Questions 1, 2 and 3 deal with the reading of daily, Sunday and evening papers respectively. Each question consists of six separate parts, *a*, *b*, *c*, *d*, *e*, *f*, and the questions are printed in parallel columns on the same page of the schedule. Within each question, parts *a*, *b*, *c* relate to the paper which the respondent read yesterday or last Sunday, while parts *d*, *e*, *f* relate to the paper the respondent reads regularly, and these two groups are again printed in parallel columns within the column of each whole question. This sounds complicated and looks complicated at first glance, but it is simple enough to work in practice. Now question 2*f* relates to Sunday papers read regularly, and 3*d*, 3*e*, 3*f* relate to evening papers read regularly. Reference to Table A shows that on these three questions B.I.P.O. interviewers showed high omission rates while the G.S.S. interviewers made no omissions, the L.S.E. students having a high omission rate on 2*f* but not the remainder.

In view of the differences in the replies which were recorded to certain of these questions, discussed in this paper, it is worth while to investigate a little more closely whether these omissions represent merely failure to record a "Does not apply". In fact, as the *e* and *f* D.N.A. percentages check with the *d* None or D.K. percentages in each case, it is clear that the omission rates of Table A relating to these questions represent failures either to put the question or to record the answer rather than the less serious failure to record a "Does not apply".

On this group of questions then we can say that both B.I.P.O. and L.S.E. showed a high rate of omission where G.S.S. completed the whole, and the B.I.P.O. rate was markedly high.

(iii) Question 8 of the reading survey was again a question contingent upon previous replies and it was subject to a special briefing instruction. The high omission rate of B.I.P.O. is no doubt again due to their unfamiliarity with this type of schedule, combined with the obscurity in the wording of the "sign post" which made the special briefing instruction necessary.

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Question CVIII is the classification question on income. In every questionnaire the B.I.P.O. and L.S.E. interviewers show a high omission rate on this question, whereas the G.S.S. interviewers complete almost all. It is possible that these omissions represent refusals of the respondent, and that the G.S.S. recorded these refusals in the appropriate place while the other two organizations did not. The following table, whose percentages are based on the answers to the income question for all questionnaires combined, makes it clear that this was not so.

Percentages of Interviews giving Certain Results on Income Question for all Questionnaires

	a "*Don't know*"	b *Refusal*	c *Omitted*	a + b + c	*Sample Number*
G.S.S. . . .	—	4	—	4	428
B.I.P.O. . . .	2	6	5	13	407
L.S.E. . . .	1	7	5	13	349

Had the total proportion of "Don't know", refusal and omission been much the same for the G.S.S. as for the other two organizations, the hypothesis of the omissions being concealed refusals might have been tenable; but this is not so; indeed B.I.P.O. and L.S.E. show each a higher D.K. and refusal proportion than G.S.S., twice the standard error of the difference between 4 per cent. and 8 per cent. with these sample numbers being 3·4.

(iv) Question CXII of the reading classification was a question relating to education which did not appear on the classification page of either of the other two questionnaires, although in all other respects the three classification pages were identical. Since each individual interviewer was required to make interviews on all three questionnaires, there might readily arise cases in which this single extra question in the reading questionnaire was overlooked, and it would seem that the high omission rates here represent pure oversight by the interviewer.

(v) In the savings questionnaire the high omission rates are concentrated on Question 7*a* and a group of questions relating to savings certificates and accounts, Questions 15, 16, 17, 18, together with the income question and two other questions in the classification. Throughout, these omissions are virtually confined to the B.I.P.O. and L.S.E. interviewers, with very little to choose between them as regards the proportion of omissions.

Question 7*a* is a contingent question depending upon the reply to Question 7, and provision was made for a "Does not apply" code which should have been ringed by the interviewer in all applicable cases. That the high proportions of omissions by B.I.P.O. and L.S.E. represent, almost entirely, failures to ring this code is apparent from the following figures:

Percentages of Certain Replies to Question 7 *and* 7a *of Savings Questionnaire*

	Replies to Qu. 7 *Involving the Putting of Qu.* 7a	*Total Replies to Qu.* 7a
G.S.S.	41	43
B.I.P.O.	46	47
L.S.E.	43	42

Question 7*a* has in fact been put by G.S.S. and B.I.P.O. to more people than it should have been judging by the replies to Question 7; but this cannot be counted as an error, since the interviewers were instructed in all cases of doubt to put the contingent question. It is clear that with the exception of a possible maximum of two cases in the L.S.E. group there are sufficient replies to Question 7*a* to account for all the respondents to whom the questions should have been put, and therefore the unmarked schedules represent merely a failure to ring the "Does not apply" code.

The omission rates on Questions 15, 16, 17, 18 on the contrary represent a real failure either to put the question or to record the reply. Those questions were part of a series of questions dealing with the factual matters of the amounts held in savings banks, the frequency of deposit, and the change, if any, in holdings over the past year; they are contingent upon the answers to

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Questions 12 and 13 which ask whether the respondent has a savings bank account at all. In each of these questions the omissions are such that the numbers of respondents' replies recorded to the question fall short of the numbers to whom, from Questions 12, 13, it should have been put, by the number of omissions recorded. Therefore, in this series of factual questions there was an appreciable failure by both B.I.P.O. and L.S.E. either to record the replies of all their respondents or to put the question successfully to all their respondents. In Question 17, where there was a code for "refusal", if the "refusals" could be combined with the "omissions", we have G.S.S. 2 per cent., B.I.P.O. 16 per cent., L.S.E. 10 per cent., or for refusals alone, G.S.S. 2 per cent., B.I.P.O. 11 per cent., L.S.E. 6 per cent., which gives us no particular ground for supposing that the "omissions" were really "refusals."

In the classification questions of the savings questionnaire, income again comes in for high omission by L.S.E. And for some reason which is not clear the marital status and age entries are omitted by a high proportion of both B.I.P.O. and L.S.E. although this is not the case in the other two questionnaires.

(vi) In the tuberculosis questionnaire only three questions other than the income question already discussed showed omission rates of 5 per cent. or higher. Questions 8*a* and 8*b* were both contingent questions, 8*a* dependent on the reply to question 7, and 8*b* on 8*a*. Further, there was here a misprint in the sign-posting on the schedule which had to be verbally corrected during the briefing. The high rates of omission are almost certainly due to confusion over this correction of the printed form, but it is of interest to note that it was the G.S.S. who showed the highest of these rates, in view of the fact that this was a questionnaire designed by B.I.P.O. Question 14*d* again shows a high rate of omission by G.S.S. and a lower rate by the other two organizations.

(vii) To sum up this investigation of the mechanical completeness of the interviewers' recording, it could be said that unfamiliarity and complexity are the factors tending to cause omissions. The process of going through the schedule and recording replies is for the interviewer a routine, and anything which breaks this routine is liable to cause errors; for instance the extra question CXII in the reading classification. From this point of view familiarity with the general methods of the questionnaire writer is more important than the subject-matter of the inquiry or even the format of the schedule; for instance, the L.S.E. students who had no previous experience of either the G.S.S. or B.I.P.O. type of questionnaire showed almost exactly the same omission rates on reading, on savings and on tuberculosis although the format of each schedule was different, whereas the G.S.S. and B.I.P.O. showed uniformly better rates on their own and worse rates on the other's type of schedule, although the reading and savings schedules were of very different formats. Pre-coded questions were less subject to omission than open questions being more mechanical in their requirements. Almost all the questions upon which the omission rate was high, other than in the classification, were contingent questions where the interviewer had to consider at least momentarily instead of going straight ahead. Between the different types of interviewer overall there is one marked difference. The G.S.S. show a lesser proportion of omissions than B.I.P.O. or L.S.E.; the latter two are close together, with the L.S.E. students slightly more prone to omission.

Note 3.—*Number of Items Listed*

(i) As a third criterion of the amount of information recorded we have taken the number of separate items recorded in answer to certain questions and their distributions as percentages are shown in Tables B–F.

TABLE B

Reading Survey.—Question 5(a): *Can you Tell me the Names of the Magazines or Journals you Read Regularly*?

Organization	*Number of Journals Recorded*							*Total*
	0	1	2	3	4	5	6+	
G.S.S. . . .	46	18	17	11	5	1	2	100
B.I.P.O. . . .	44	31	14	3	4	2	2	100
L.S.E. . . .	44	29	13	8	4	1	1	100

d.f. 6. P. = 0·21.

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Reading Survey.—Questions 26, 27, 28.

These were three questions asking for the informant's preference among contents of reading matter, subjects of books and types of literature respectively. Each question involved the interviewer presenting the informant with a card on which were written 10, 18 and 11 items respectively and the informant indicating which item or items he chose. The informant was at liberty to choose as many items as he wished or none at all on each card. The total number of items recorded in reply to all three questions is the criterion of distribution in Table C.

TABLE C

Organization	*Number of Times Recorded*							*Total*
	0–3	4–5	6–7	8–9	10–11	12–13	14+	
G.S.S.	4	20	17	14	18	12	15	100
B.I.P.O.	22	28	14	14	13	3	6	100
L.S.E.	18	20	13	12	19	15	3	100

d.f. 8. P. = 0·09.

TABLE D

Savings Survey.—Question 20: *Are You Yourself Making any Payments for Life Insurance?*

Organization	*Number of Policies Recorded*						*Total*
	0	1	2	3	4	5+	
G.S.S.	49	27	9	4	7	4	100
B.I.P.O.	55	32	5	3	1	3	100
L.S.E.	38	47	9	3	1	2	100

d.f. 4. P. = 0·03.

TABLE E

Savings Survey.—Question 20: *Are you Yourself Making any Payments for Endowment Insurance?*

Organization	*Number of Policies Recorded*						*Total*
	0	1	2	3	4	5+	
G.S.S.	62	26	10	2	—	—	100
B.I.P.O.	68	21	7	2	1	1	100
L.S.E.	60	27	10	2	1	—	100

d.f. 4. P. = 0·38.

The interviewers were instructed to record in answer to the two questions recorded above, for each policy held, the frequency of payment, sum assured, time started and duration. Here we are only concerned with the number of policies recorded under each heading.

TABLE F

Tuberculosis Survey.—Question 9: *What is the Best Way of Treating T.B.?*

Organization	*Number of Treatments Recorded*						*Total*
	0	1	2	3	4	5+	
G.S.S.	12	32	28	21	7	—	100
B.I.P.O.	12	40	22	21	4	1	100
L.S.E.	14	38	28	18	2	—	100

d.f. 6. P. = 0·60.

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To this question, as usual for open questions, the interviewers were instructed to record as far as possible the respondent's own words and, failing that, a synopsis of what he said. The replies consisted of suggestions of Rest, Fresh Air, Good Food, Medical Treatment, and other forms of treatment either singly or in combination. We have taken here the number of distinct types of treatment mentioned together by each respondent.

(ii) The distributions resulting for each of these questions have been tested by the χ^2 test for homogeneity between organizations in their recorded replies. The resulting probabilities are shown below each tabulation. Considering in detail only distributions giving probabilities less than 30 per cent., we see that the G.S.S. is getting a slightly higher number of journals recorded (Table B) and a higher number of preferences mentioned in reading (Table C), whilst L.S.E. record a low proportion without life policies and a high proportion with one such policy (Table D).

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The Sources and Nature of Statistical Information in Special Fields of Statistics

Statistics of Advertising

By Mark Abrams

Any discussion of the statistics of advertising must start by acknowledging the impossibility of arriving at a completely satisfactory definition of "advertising". The impressive study by Kaldor and Silverman opens with the declaration that "The guiding principle adopted was that the term 'advertising' should cover any activity designed to spread information with a view to promoting the sales of marketable goods and services" (p. 2).

A rigid adherence to this definition immediately comes up against some obvious difficulties. For example, newspapers invariably count as part of their advertising revenue the fees received for insertions in their "births, deaths and marriages" columns, although these announcements have nothing to do with "promoting the sales of marketable goods and services".

Again, every advertising agency and advertising medium would describe as advertising expenditure the money spent by Government departments and public corporations on campaigns urging housewives to reduce their consumption of electricity, encouraging young men to volunteer for the Regular Army, exhorting pedestrians and motorists to learn the Highway Code.

And what about the money spent by various business organizations in 1949 to warn the electorate of the dangers of nationalization? Those who spent the money, those who handled it and those who received it were all agreed in entering it in their ledgers as "advertising expenditure".

Presumably, a reasonably comprehensive definition would run roughly as follows: Advertising expenditure comprises all money spent on buying and using facilities in any medium of communication, either to convey information to a third party or to attempt to influence his views or behaviour. Advertising could then be defined as the content of these messages, and the manpower employed in advertising would consist of all those engaged in the preparation and distribution of such messages.

In the statisticians' paradise there would be no difficulty in collecting statistics of advertising based on these definitions. In the more humdrum world of to-day, however, we have to accept something less and try to work with figures based both on restricted and fluctuating definitions and on estimates arrived at, only too often, by little more than courageous ingenuity.

The available material can perhaps be best reviewed by considering in turn the four outstanding studies of advertising statistics:

1. The first of these to appear was F. P. Bishop's *The Economics of Advertising*. During the inter-war years there was a thin but steady flow of books concerned with the "economics of advertising". Some were by professional economists newly stimulated by the growing discussion of the economics of imperfect competition; others were written by publicists fearful of what they held to be the social evils inherent in an advertisement-ridden society. And of course there were the apologias of the advertising men themselves. Common to most of these efforts were tables of statistics of advertising expenditure. The tables, however, bore little resemblance to each other. Thus, of two equally eminent authorities on advertising, both dealing with the year 1930, one put the total annual expenditure at £180 millions, while the other put the total at no more than £70 millions.

One of the principal attractions of Mr. Bishop's study is that he reviews all the more serious attempts at estimation that had appeared in the pre-war years, and then on the basis of this critique, of his own calculations and of his long and very rich experience in advertising puts forward a set of figures which were soon accepted as "reasonable" by most people then giving careful and intelli-

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*Estimated Annual Expenditure on Advertising,** 1935–38

	£ 000's
In the Press†	35,000
Posters (exclusive of printing)	5,000
Other outdoor advertising	2,500
Direct mail (exclusive of printing)	5,000
Window and shop display	10,000
Radio	1,500
Films	500
Printing (including Posters and Direct Mail)	15,000
Administration	6,000
	80,500

* Mr. Bishop's definition of advertising is fundamentally that of Kaldor & Silverman, i.e., the emphasis is primarily on facilities bought for the purpose of promoting the sales of goods and services.
† Including expenditure on classified advertisements.

2. In 1942 the Advertising Association proposed to the National Institute of Economic and Social Research that it carry out an inquiry to establish "the economic facts about advertising". The Institute entrusted the task to N. Kaldor and R. Silverman, and the authors were from the very beginning assured of the friendly co-operation of many of the largest advertising agencies, many of the owners of advertising media, of advertisers, and of the trade and professional associations organized by the various interests concerned with advertising. According to the jacket of their book:

> "The year 1935 is taken as the base year and the period 1934–38 is submitted to detailed investigation. Earlier and later periods both present substantial obstacles to accurate measurement, but estimates of the revenue of the Press are provided for the period 1920–44. The three major topics of the inquiry may be summarized:
>
> "(i) Total expenditure on advertising in the United Kingdom and its classification by (a) forms of advertising, (b) commodities advertised, and (c) industries providing the services.
>
> "(ii) Advertising expenditure as a percentage of manufacture and retail sales by commodity groups, and the degree of concentration within these groups by firms.
>
> "(iii) Revenue of the Press with special reference to the contribution of advertising to total gross and net revenue".

(1) *Total Expenditure on Advertising*

(i) (a) *Total Expenditure by Forms of Advertising*

The authors estimated that in 1935 the total expenditure on advertising was £89,360,000 (± £4,520,000), and that the annual average for 1935–38 was £92 millions. This latter estimate is some 14 per cent. higher than the figure given by Mr. Bishop, and a comparison of the individual items within the total shows even larger differences. In the following table I have attempted to rearrange Mr. Bishop's figures so that they conform with the categories used by Kaldor and Silverman.*

Thus, the rough resemblance between the two totals (£90 millions and £80 millions) is seen to be largely fortuitous. There is approximate agreement on direct mail, films and administration. The difference in the estimates of expenditure on radio may be explained by the fact that Messrs. Kaldor and Silverman are concerned with the year 1935, while Mr. Bishop's figures include three later years when this form of advertising was expanding steadily. Both studies, but particularly Kaldor and Silverman, probably over-estimated expenditure on direct mail advertising.

Far and away the largest single absolute discrepancy, however, relates to expenditure on Press advertising. It is probable that the true figure lies about half-way between the £48 million and

* This involves primarily the allocation of his item "printing".

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Total Annual Expenditure on Advertising in U.K. (£000's)

	Kaldor and Silverman, 1935	*Bishop*, 1935–38
Press	48,360	35,000
Outdoor	6,500	10,000
Radio	400	1,500
Film	550	500
Direct mail	11,500	10,000
Window and shop display	6,500	12,500
Advertising accompanying goods	7,500	5,000
Miscellaneous	2,050	..
Advertising departments and administration	6,000	6,000
	89,360	80,500

the £35 million given by our authors. Mr. Bishop has almost certainly omitted some of the expenditure on the minor publications which have been included in the Kaldor-Silverman study, while the latter, while allowing for them, have probably underestimated the discounts allowed to some advertisers (e.g., department stores) by the owners of publications.

(i) (b) *Total Expenditure by Commodities Advertised*

One of the main reasons Kaldor and Silverman chose 1935 as their base year was that the results of the Census of Production for that year made it possible for them to relate advertising expenditure to manufacturers' net sales, and thus give a picture of the incidence of these expenditures in relation to other costs and to consumers' expenditure. Their relevant table on the latter relationship shows that in 1935 there were very considerable variations between different commodity groups. Thus, advertising expenditure was equivalent to 15 per cent. of total consumers' expenditure on toilet goods and only 0·9 per cent. of expenditure on food.

The following table summarizes the material given on pp. 26 and 27 of the book:

Commodity Group	*Consumers' Expenditure* (£ *million*)	*Advertising to the Consumer* (£ 000)	*Advertising as Percentage of Expenditure*
Food	1,100	9,469	0·9
Drink	285	3,598	1·3
Tobacco	153	3,954	2·6
Rent, rates, water	450	..	..
Fuel and light	185	1,334	0·7
Household stores	47	2,816	6·0
Household equipment	183	4,582	2·5
Household entertainment	38	1,639	4·3
Clothing	392	3,431	0·9
Toilet goods	27	4,029	15·0
Medical goods	35	5,863	17·0
Vehicles and accessories	156	4,634	3·0
Miscellaneous goods	168	4,617	2·7
Travel and transport	150	3,172	2·1
Entertainment and amusement	108	3,431	3·2
Miscellaneous services	400	2,080	0·5
Total	3,877	64,842*	1·7

* Total includes £6,193,000 of unallocated retailers' advertising.

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(i) (c) *Total Advertising Expenditure by Industries Providing the Services*

The authors estimate that in 1935 almost half the total expenditure on advertising was spent on buying space in the Press, and that this provided the publishers of newspapers and periodicals with 57 per cent. of their revenue (i.e., revenue after the deduction of wholesalers' discount, advertising agents' commission and payments made to outside transport operators). Undoubtedly since 1945, while the Press has continued to attract the greater part of all advertising expenditure, this revenue no longer provides publishers with the bulk of their total net revenue.

The Contribution of Advertising to the Revenue of Certain Industries, 1935

Industry	*Advertising Revenue* (£ 000)	*Percentage of Total Advertising*	*Percentage of Total Output of Industry*
Publishers of newspapers, periodicals	43,720	49·0	57
Printing, etc., stationery, cardboard box trades	23,600	26·4	28
Poster and sign contractors	2,850	3·2	100
Public transport operators	2,200	2·4	1
Broadcasting companies	170	0·2	100
Film producers and distributors	300	0·3	2
Film exhibitors	250	0·3	1
Post Office	2,000	2·2	2
Addressing firms	500	0·6	100
Miscellaneous trades (paint, etc.)	1,070	1·1	..
Advertising agents	6,700	7·6	100
Advertising departments, personnel, consultants	6,000	6·7	100
Total	89,360	100·0	

(ii) *Concentration of Advertising Expenditure*

Advertising expenditure is largely a concomitant of the marketing of branded consumer goods, and heavy and concentrated advertising expenditure is found in commodity groups where there is sustained and intense competition between three or four "leaders" to hold and expand their share of brand conscious markets. The authors, limiting themselves to press display advertising (approximately one-third of all advertising expenditure), analyse the material for 1938 and show that in that year less than one hundred advertisers accounted for almost 30 per cent. of all Press advertising expenditure. The same degree of concentration almost certainly exists to-day.

Commodity Group	*Number of Advertisers Spending £50,000 or more*	*Their Expenditure as Percentage Total Press Advertising*
Food	17	49·4
Drink	6	33·0
Tobacco	6	70·6
Household stores	6	44·4
Household equipment	1	5·3
Household entertainment	3	31·5
Clothing	1	4·9
Toilet goods	8	30·5
Medical goods	18	41·2
Vehicles and accessories	9	38·8
Other goods and services	11	9·2
Total	86	26·9

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(iii) *Revenue of the Press*

In addition to their analysis of the net revenue of the Press, the authors provide in Chapter IV estimates for 1935 of national gross expenditure on newspapers and magazines. In that year readers spent £56,685,000, "display" advertisers £42,830,000, and classified advertisers £5,530,000. These total figures, however, include wide variations—for the suburban and provincial weeklies, and for trade and technical journals advertisers' expenditure far outdistanced readers' expenditure. Since 1935 there have been considerable changes. For 1951 readers' expenditure will far outdistance advertisers' expenditure, and "general interest" magazines—a relatively unimportant recipient in 1935 of both the advertisers and the general public's money, has become at least the equal of the national daily newspapers.

3. The publication of the Kaldor and Silverman study in 1948 aroused a great deal of interest among people whose livelihood depended directly on advertising. At the same time there was a disappointed awareness that statistics describing 1935 conditions would have little relevance to 1948 controversies and problems. The Advertising Association, therefore, decided to commission a new inquiry. The task was entrusted to Mr. Silverman, one of the authors of the earlier study; Mr. W. B. Reddaway acted as economic and statistical adviser to a guiding committee under the chairmanship of Colonel G. Warden, and Messrs. Price, Waterhouse and Co. undertook the task of receiving, analysing and summarizing the confidential information provided by advertisers, advertising agents and owners of advertising media.

Two main changes were effected in the later study. No attempt was made to report information about the expenditure on advertising particular types of products. The present analysis shows merely the total of advertising expenditure, its distribution among the main media, and the contribution of advertising to the revenue of various trades and industries. The second main difference is to be found in the methods employed to collect the post-war information; questionnaires were sent to three groups of people—those who spend money on advertising, those who own advertising facilities and produce advertising material, and those who act as intermediaries between the advertisers and the media owners. They were asked to provide expenditure figures for 1938, 1947 and 1948. Inevitably only a fraction of the questionnaires were completed and returned, but those responsible for the report were able to "marry" the information received from the three main sources and to draw upon a good deal of experience and judgment. The estimates finally presented by Mr. Silverman are likely to be regarded as reasonably accurate by most people with some knowledge of advertising finance. Clearly, however, both the total and the figures for subgroups cannot be used without making allowances for substantial margins of error.

The following table summarises the new figures, and sets them against the earlier Kaldor and Silverman estimates for 1935:

Total Annual Expenditure on Advertising in U.K. (£ 000's)

	Kaldor and Silverman	*Silverman*	
	1935	1938	1948
Press	48,360	47,280	66,180*
Outdoor	6,500	6,300	15,360
Radio	400	1,700	50
Film	550	750	2,690
Direct mail	11,500	4,800	5,000
Dealer aids	6,500	6,750	4,700
Other printed matter	7,500	15,500	13,500
Exhibitions†	..	..	8,200
Free gifts and samples†	..	..	720
Miscellaneous	2,050	..	1,070
Administrative costs, etc.	6,000	6,400	7,000
Total	89,360	103,000‡	124,470

* Includes £6,550,000 for block and art charges. An estimate for these charges was not included in 1935; for 1938 they are merged in the total figure and are not included in the press figure.

† Omitted in the 1935 study as separate categories.

‡ The figures in this column come to a total of £89,480,000. To arrive at £103,000,000 Mr. Silverman, on the basis of internal evidence, has added £13,500,000 to allow for expenditure on exhibitions, free gifts and samples and miscellaneous items, etc.

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Since 1948 expenditure on Press advertising is known to have increased by approximately 50 per cent. Mr. Silverman, at one point in his book, takes the step of assuming that expenditure on all other items in his advertising "bill" increased between 50 per cent. and 100 per cent. He therefore suggests that for 1950 the total rose to between £170 millions and £185 millions, and was equivalent to approximately 1·6 per cent. of the national income for that year. Even if one makes the much more conservative assumption that all increased advertising expenditure since 1948 has been concentrated on the Press, one is still left with a total of £158 millions for 1950 or 1·4 per cent. of the national income. In 1938 the ratio was 2·2 per cent., and in the United States for the year 1950 advertising expenditure was equivalent to 2·4 per cent. of the national income.

4. In addition to these three books there is the *Statistical Review of Press Advertising*. This quarterly volume is the most comprehensive body of continuing statistics concerned with advertising expenditure. It is, however, limited to expenditure on Press advertising. The foreword to the latest issue available at the time of writing declares:

> "Our records continue to cover most classes of display advertising of branded articles recorded from approximately 8,500 issues of publications per month. In general, advertisements have been priced at single insertion scale rates, except in certain newspapers and magazines, where special rates applying to solus and facing matter positions have been taken into account. In some industries the amounts recorded include all dealer as well as direct advertising".

In using the *Statistical Review* figures three cautions should be kept in mind:

(*a*) They do not include expenditure on classified advertisements. It is probable that in recent years expenditure on classified advertisements forms a much larger proportion of total Press advertising expenditure than before the war. It is not uncommon nowadays for manufacturers of branded goods with nation wide markets to use this form of advertising.

(*b*) The statistics do not relate to all publications which carry advertising.

(*c*) The statistics include expenditure on department store advertising but such expenditure has always been assessed at "standard" rates. In fact, before the war a good deal of this advertising was placed at less than standard rates. The *Statistical Review* figures therefore overstate pre-war expenditure on store advertising, but there is no comparable inflation of the post-war figures.

The detailed tables of each quarter's issue of the *Review* classifies all advertising (including Governmental and public boards) by product; within each product group there is listed each "make" and against each of these is shown the name of the manufacturer, his advertising agent and the total Press expenditure for each of the three months of the quarter. Summary articles deal with expenditure by media groups (e.g., magazines, national Sunday papers, trade papers, etc.), and by product groups (e.g., toilet and beauty preparations, household equipment, etc.). From the material given in the *Review* it is, of course, also possible to calculate the Press advertising turnover of each advertising agency.

The special supplement to the 6th July, 1951, issue of the *World's Press News* contained, among other things, an article by Mr. Jesse Scott, managing director of the Legion Publishing Company. In this he brings together material from the summary tables published in the *Statistical Review* over the past fifteen years and provides the following figures of total Press advertising (as defined by the *Review*):

Total Press Advertising Recorded by Statistical Review

Year	£ 000's	*Year*	£ 000's	*Year*	£ 000's
1934	23,393	1940	17,442	1946	16,908
1935	25,633	1941	13,568	1947	20,624
1936	27,636	1942	13,415	1948	21,778
1937	29,198	1943	13,851	1949	30,523
1938	28,692	1944	14,593	1950	36,914
1939	23,482	1945	14,547		

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Thus, in Mr. Scott's table the 1935–38 annual average is £27,800,000; the discrepancy between this and Mr. Bishop's estimate of £35,000,000 is largely due to the latter's inclusion of classified advertising.

The article in the *World's Press News* supplement also surveys the *Review's* material "built upon records of Press advertising covering some 180 categories of goods and services advertised *to the consumer*". The totals of expenditure dealt with here are, of course, less than those shown in the preceding table. (In most years expenditure on goods and services advertised to the consumer are about 70 per cent. of total Press advertising expenditure covered by the *Statistical Review*). Over the past fifteen years there have been some striking changes in the proportions of total expenditure devoted to the main product groups.

*Press Advertising Expenditure on Consumer Goods and Services**

	Percentage of Total 1935–6–7	*Percentage of Total* 1948–9–50
Food and drink	24·4	23·3
Medicinal	15·4	13·2
Motors and cycles	11·2	8·4
Household equipment	12·3	10·9
Household stores	9·7	12·4
Toilet, beauty preparations	7·9	15·1
Cigarettes, tobacco	9·1	2·9
Wearing apparel	6·0	10·6
Radio and music	4·0	3·2
Total	100·0	100·0

* The average annual total for 1935–6–7 was £20,185,000; for the later period £20,905,000.

The same article contains an analysis of advertising expenditure by type of publication, and here too there have been some striking changes. In 1935 only 17·2 per cent. of Press expenditure went to magazines; by 1950 their proportion of the total had risen to 36·2 per cent.

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There are three weekly "trade" papers which are largely concerned with advertising—*Advertisers' Weekly*, *World's Press News*, and *Newspaper World*—and each of them publishes from time to time statistics bearing on advertising expenditure. The main "trade" associations are the Advertising Association, the Incorporated Advertising Managers' Association, the Incorporated Society of British Advertisers, the Incorporated Sales Managers' Association, and the Institute of Incorporated Practitioners in Advertising; details about them is published in the *Advertiser's Annual*. This year-book lists, among other things, all advertising agents and their clients, and is a complete directory of all aspects of advertising.

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The Sources and Nature of Statistical Information in Special Fields of Statistics

The Statistics of British Insurance

By A. G. Herbert and R. D. Clarke

Introduction

1. *Types of Insurer*

The sources from which the statistics of British insurance may be extracted vary primarily according to type of insurer. Thus one source will summarize statistics for friendly societies, another will be concerned with assurance companies, a third with Lloyd's and so on. This form of subdivision inevitably complicates the task of an investigator who wishes to collate statistics for a particular branch of insurance, since to accomplish his task he will need to consult an assortment of publications of varying provenance.

The following list indicates the principal types of insurer transacting insurance business in the United Kingdom at the present time:

Assurance companies.
Friendly and collecting societies.
Trade unions.
Trustees of private superannuation funds.
Lloyd's and similar approved associations of underwriters.
The State.

The statistics available for each of the above types of insurer will be reviewed in successive sections of this note. First of all, however, a description will be given of the classes of business transacted.

Classes of Business

2. *Life Assurance and General Insurance*

The main classes into which insurance business is divided are defined by the Assurance Companies' Acts, 1909–46, which *inter alia* lay down the form in which statements of information must be presented to the Board of Trade. One major classification needs, however, to be stressed at the outset. This is the distinction between life assurance on the one hand and non-life, or general insurance as it is commonly called, on the other. Although the nature of this distinction will be self-evident, the reason for regarding it as more fundamental than that between, say, fire and accident insurance may not be at once apparent. Under most contracts of general insurance a year's premium covers a year's risk; and although for various reasons it is essential to hold certain reserve funds, there is no need to accumulate premiums over long periods to meet future contingencies. For almost all types of life assurance the reverse is true, and actuarial reserves, depending upon the combination of interest functions with probabilities, have to be built up to meet future liabilities. One consequence of this is that life assurance contains a large element of investment, and the companies which transact life assurance, considered collectively, form the largest group of institutional investors in the country.

At this point it may be as well to explain an idiomatic quirk in terminology. The word "assurance" is normally used in relation to life business and "insurance" in relation to general business. When an inclusive or generic term is required "insurance" is most commonly employed; but in consequence of the precedent set by the Acts of Parliament already mentioned, it is proposed in this note to refer to "assurance companies" rather than "insurance companies." Such idiosyncrasies of English usage are undeniably tiresome, but this is not the place to attempt any break with convention.

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3. *Classification of Life Assurance*

There are two classes of life assurance, viz., ordinary and industrial, the distinction between them depending upon the manner in which premiums are paid. Under industrial life assurance premiums are collected from the policyholder's home at weekly, fortnightly, or four-weekly intervals. Under ordinary life assurance the policyholder sends his premiums to the office or its representative, and the interval between premiums is never less than a calendar month and is usually either quarterly or annual.

A contract of life assurance normally provides, in return for a premium or series of premiums, for a sum assured to be paid either upon death or upon survival of a given term. Ordinary life business includes the issue of annuities, which may be purchased either by a lump sum or by a series of premiums terminating before the commencement of the annuity. It also embraces group life and pension business under which contracts are made with firms of employers to provide life assurance and pension benefits for employees in return for regular contributions usually (though not necessarily) depending upon salary.

Annuities and group life and pension business are not transacted in the industrial life assurance class.

4. *Classification of General Insurance*

General insurance business falls into the following classes:

Accident.
Fire.
Motor vehicle.
Marine, aviation and transit.
Miscellaneous.
Capital redemption.
Bond investment.

Consideration of the two final items in this list, since they are of a rather special character, will be postponed to the next sub-section.

Most of the classes of business detailed above are self-explanatory. Accident insurance includes sickness and disability business. When referring to the sickness benefits insured by friendly societies, the term "sickness insurance" is always used.

Miscellaneous insurance is a residual category containing all types of insurance business not covered by the other classes. Prior to 1948 there was a separate class designated "employers' liability insurance". However, this is now included in the miscellaneous class, since most of the business disappeared when the industrial injuries section of the national insurance scheme began to operate.

5. *Capital Redemption and Bond Investment Business*

Capital redemption insurance is not in any real sense a form of insurance at all. Its contracts are financial transactions depending solely on the operation of compound interest, and they provide for the payment of a fixed sum at the end of a stated period in return for either a single payment or a series of payments. Capital redemption insurances are sometimes referred to as "sinking fund policies".

Capital redemption business is normally regarded as a class of general insurance. However, its investment character suggests close affinity with life assurance; and indeed many life assurance offices which transact no other classes of general insurance nevertheless transact capital redemption business. Such offices are not deemed thereby to have become "composite" offices (i.e., offices transacting both life and general insurance), but on the contrary are still classified as life offices.

Capital redemption business also includes annuities certain, i.e., annuities payable for a fixed term without any dependence upon life. However, many assurance companies in making their returns of information include their annuities certain with other annuity business in the ordinary life assurance class. Consequently it is peculiarly difficult to obtain definitive information about annuities certain.

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Bond investment insurance closely resembles capital redemption business except that premiums are collected from the policyholder's home at frequent intervals after the manner of industrial life assurance. The total amount of bond investment business being transacted at the present time is very small, and only the fact that it is specifically defined as one of the main classes of insurance in the Assurance Companies' Act 1909 justifies its being mentioned here at all.

ASSURANCE COMPANIES' STATISTICS

6. *Types of Company*

The principal source for the statistics of assurance companies is the *Summary of Statements of Assurance Business deposited with the Board of Trade* which is published annually by H.M. Stationery Office. This *Summary* is compiled by the Board of Trade from the individual statements returned by assurance companies under the provisions of the Assurance Companies' Acts 1909–46. Before the war of 1939–45 a comprehensive volume was published in which each individual statement was reproduced in full. This has been discontinued in recent years, although it is intended to re-commence publication in the near future.

The most recent (1951) issue of the *Summary* embraces 285 British assurance companies, which may be classified as follows:

Classes of Business Transacted	*Number of Companies*
Ordinary life assurance only	31*
Industrial life assurance only	2
Ordinary and industrial life assurance	4
,, life and general insurance	43
,, and industrial life and general insurance	8
Total transacting life assurance	88
General insurance only	197
	285

* As explained in sub-section 5 some of these companies also transact capital redemption business.

In addition, information is given in respect of 49 overseas companies transacting business in the United Kingdom.

Much of the information about industrial life assurance is not included in the *Summary* but is contained in a separate publication issued by the Industrial Assurance Commissioner. However, certain of the statistical tables, viz., those which summarise the companies' profit and loss accounts and balance sheets, relate to all classes of insurance combined, and thus automatically include the industrial life class.

It should be noted that, as the result of a legal idiosyncrasy, a company which transacts only plate glass insurance is not an assurance company. Moreover, not all assurance companies are companies within the meaning of the Companies' Act. Among the exceptions are the mutual assurance companies. These have no shareholders and are in effect associations of policyholders. Frequently they describe themselves as "assurance societies", and logicians may care to reflect on a situation whereby a mutual assurance society, though not a company, is nevertheless an assurance company and not a friendly society.

7. *New Ordinary Life Assurances*

The 1951 *Summary* was compiled from returns deposited with the Board of Trade during 1950, and these for the most part related to the calendar year 1949. For a few assurance companies it is true the year of account is not identical with the calendar year. Consequently it is not possible to use a uniform period when totalling statistics for all companies combined. However, the amount of error involved by this anomaly can only be slight.

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The first item in the *Summary* is a table of new life assurances effected. The following data are recorded:

Number of policies issued.
Sums assured.
Single premiums.
Yearly renewal premiums.

These data are subdivided into three sets, viz.,
Business effected in the United Kingdom by British offices,
" " " " by overseas offices,
" " outside the United Kingdom by British offices,
and the totals for each set are given in the following table:

New Ordinary Life Assurances Recorded in Statements deposited with the Board of Trade during 1950

	No. of Policies	*Sums Assured* £	*Single Premiums* £	*Yearly Renewal Premiums* £
U.K. business—				
By British offices .	555,584	461,856,126	2,958,517	18,368,745
By overseas offices .	35,974	42,283,653	122,168	1,782,630
Total . .	591,558	504,139,779	3,080,685	20,151,375
Overseas business—				
By British offices .	82,755	64,986,103	431,658	2,340,394

8. *Ordinary Life Assurance Revenue Accounts*

Several of the most valuable items in insurance statistics are derived in the first place from the companies' revenue accounts. Among these are the premium income, the interest earnings, the claims paid and the expenses of administration. For life assurance the amount of the fund at the beginning and end of the year is also important; but although this is included in the revenue account it is better obtained from the balance-sheet, where not only the life assurance fund itself but also any additional reserve funds will be shown.

The *Summary* contains a schedule summarizing the ordinary life assurance revenue accounts for British companies, and another for those overseas companies transacting ordinary life business in the United Kingdom. Many, though not all, of the items in both schedules are subdivided according as they relate to business transacted within or outside the United Kingdom.

For the year of account in respect of which returns were deposited with the Board of Trade during 1950, the total premium income for ordinary life business transacted in the United Kingdom was:

	£
By British companies	166,616,524
By overseas companies	13,080,046
	179,696,570

Payments to policyholders in settlement of claims, annuities, etc., were:

	£
U.K. business by British companies .	107,696,670
" " by overseas companies .	10,440,082
	118,136,752

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Corresponding figures for the overseas business transacted by British companies were:

	£
Premiums	19,226,843
Payments to policyholders . . .	9,026,138

Among other items obtainable from the schedule summarizing the companies' revenue accounts are interest, expenses and profits. However, these are not subdivided as between business transacted within and outside the United Kingdom. Nor, indeed, are the amounts of the life assurance fund at the end of the year of account. The total life funds of British companies recorded in the 1951 *Summary* exceeded £1,573 million, an increase of £95 million during the year.

9. *Ordinary Life Assurances in Force*

At intervals of not more than five years every British company transacting life assurance must make an actuarial valuation of its liabilities, and render a statement of the results in a prescribed form to the Board of Trade.

The information extracted from these statements and published in the annual *Summary* is somewhat limited, being confined to the numbers of policies and sums assured in force at the most recent valuation date within certain classes of policy. The primary classification depends on whether policies are or are not entitled to participate in profits. Each of these categories is then subdivided according to

Whole of life assurances,
Endowment assurances,
Joint life assurances,
Other classes.

Separate figures are given for annuities substituting amount of annuity for sum assured and distinguishing between immediate (payable from the issue of the contract) and deferred (payable from a date subsequent to the issue of the contract) annuities.

The 1951 *Summary* gives the following totals for assurances in force. (*N.B.*—Figures relate to business transacted both within and outside the United Kingdom by British offices):

	Number of Policies	*Sums Assured** £
Participating in profits .	5,390,636	2,058,059,881
Not participating in profits .	1,841,252	1,379,788,054
	7,231,888	3,437,847,935

* For participating assurances the sums assured include bonuses declared out of past distributions of profits.

For annuities the totals were:

	Number of Annuities	*Amount of Annuity* £
Immediate . . .	141,394	11,115,353
Deferred	678,135	72,078,420

A high proportion of the deferred annuities are effected by means of group pension policies, and the annuity in force thereunder is a measure of the extent to which retirement pensions due under the national insurance scheme are being supplemented through contracts secured with assurance companies. The business is rapidly growing, the amount of annuity having increased by over £20 million since the previous year's issue of the *Summary*. It is to be regretted that the *Summary* does not collate the reserves held by the offices in respect of this business, since they are available in the original returns deposited with the Board of Trade. The growth in pension reserves, re-

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presenting money saved in the present to provide future retired persons with a larger share of the national income, is a feature of some interest to economists and others.

Some additional information concerning group business is contained in a statement of "British Life Assurance Statistics" published by the Life Offices' Association and Associated Scottish Life Offices. This gave the following figures for group pension schemes in force on December 31st, 1949:

Estimated number of persons included within the schemes	855,000
Pensions in course of payment	£2,138,651 per annum
,, not yet in course of payment	£88,983,818 ,,
Premiums received during 1949	£28,326,066

These statistics are more recent than the Board of Trade *Summary* since they show the position at the end of 1949. The data included in the *Summary*, on the other hand, relate to the latest valuation during the past five years.

10. *Revenue Accounts for General Insurance*

The *Summary* now passes from life assurance to general insurance. Statements of new business or of business in force have little meaning for general insurance, and the index to measure the volume of business transacted is the premium income. Unfortunately, owing to the international character of general insurance, no subdivision between business transacted within and outside the United Kingdom is practicable. As with life assurance, the *Summary* distinguishes between British companies and overseas companies transacting business in the United Kingdom. The statistics for the latter class, being world-wide, are of limited value, and are not relevant to any study of British insurance.

The following table shows the total (world-wide) premium income secured within the various classes of general insurance by British companies during the year of account for which returns were deposited with the Board of Trade in 1950.

Class of Insurance	*Premium Income* £
Accident	9,602,268
Fire	146,179,818
Marine, aviation and transit	55,617,879
Motor vehicle	84,690,148
Miscellaneous	75,578,259
Total	371,668,372

Besides the classes shown in the above table, the *Summary* also publishes revenue accounts for capital redemption and bond investment business.

11. *Profit and Loss Accounts and Balance-sheets*

The profit and loss account and balance-sheet of an assurance company are not subdivided according to class of business, but relate to all the classes of business which the company transacts. Although both these items are collated in schedules included in the Board of Trade *Summary*, the profit and loss account is of accounting rather than statistical interest and need not be discussed here. The balance-sheet, on the other hand, has considerable statistical importance, since it exhibits the distribution of assurance companies' assets over different classes of investment.

Of the £3,148 million assets of British assurance companies at the end of the year of account covered by returns deposited in 1950, £2,935 million related to companies transacting life assurance (either with or without general insurance) and £213 million to companies transacting general insurance only. The assets of offices transacting life assurance include those held in respect of industrial life business—a class of assurance which, as already explained, is elsewhere excluded from the *Summary*.

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The distribution of British assurance companies' assets according to class of investment is shown in the following table:

	£ *million*
British government securities	1,167
Dominion and colonial government securities	129
Foreign government securities	174
Securities of Public Boards and local government authorities	102
Mortgages and loans	244
Land and property	174
Debentures	269
Preference stocks and shares	245
Ordinary ,, ,,	341
Miscellaneous	303
	3,148

Similar information is given for overseas companies transacting business in the United Kingdom, but as the figures are world-wide they are not relevant to a study of British insurance.

12. *Comparative Summaries*

A useful inclusion in the *Summary* is a series of short tables summarizing for each class of business the aggregate totals of the principal items of information over the last ten years. Thus, as an illustration of what may be found in these tables, the total (world-wide) premium income received by British companies in 1940 and 1949 for three main classes of business is reproduced below:

	Fire	*Motor Vehicle*	*Ordinary Life*
	£	£	£
Premium income in 1940	51,027,000	31,913,000	96,405,000
,, ,, in 1949	146,180,000	84,690,000	185,844,000

INDUSTRIAL LIFE ASSURANCE

13. *Industrial Assurance Statistical Summary*

Industrial life assurance is an exception to the rule that insurance statistics are separately published for each type of insurer. Owing to the existence of an Industrial Assurance Commissioner charged with the task of supervising industrial life business in the United Kingdom, an annual Statistical Summary is published in which information concerning both types of insurer involved, viz., assurance companies and collecting societies, is brought together and summarized. Consequently, as has already been noted, industrial assurance is excluded from the Board of Trade *Summary* of assurance companies' statistics discussed in earlier sections except in so far as profit and loss accounts and balance-sheets, by embracing all classes of business combined, automatically cover industrial assurance with the rest.

A collecting society is a registered friendly society transacting industrial assurance irrespective of whether any other class of insurance is also transacted. Like any other friendly society it is an association of persons for mutual benefit, and it is subject to the provisions of the Friendly Societies' Acts and not to the Assurance Companies' Acts. However, the Industrial Assurance Acts apply equally to assurance companies and collecting societies.

The *Industrial Assurance Statistical Summary* (hereafter referred to as the "*I.A.S.S.*") gives statistics for a period of eleven years in a similar form to the comparative summaries for other classes of assurance included in the Board of Trade *Summary* and described in sub-section 12 above. The figures published are aggregates for all companies and for all societies, no information being given for individual companies and societies. Table (1) of the *I.A.S.S.* relates to the industrial life business of assurance companies. Table (2) relates to collecting societies, and gives statistics

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both for industrial assurance and also for "benefits other than industrial". The nature of these "other benefits" is not specified, but reference to the published reports of the larger societies shows that they consist mainly of ordinary life assurance. The Industrial Assurance Commissioner is also Chief Registrar of Friendly Societies, and it is in this latter capacity that he receives and publishes information on classes of business other than industrial assurance. Table (3) of the *I.A.S.S.* is a combined statement aggregating industrial assurance statistics for both companies and societies. Lastly, table (4) gives a statement concerning new and discontinued assurances during the final year of the eleven-year period. This is compiled from returns furnished in accordance with regulations made under section 13 of the Industrial Assurance and Friendly Societies' Act 1948.

The most recent issue of the *I.A.S.S.* available at the time of writing relates to the period 1939–49. The principal items of information in respect of industrial assurance in 1949 are shown in the following table:

	Number of Companies or Societies	*Sums Assured by New Policies Effected During the Year* £	*Total Premium Income Received During the Year* £	*Industrial Life Assurance Fund at the End of the Year* £
Assurance companies.	14	184,002,000	100,334,000	671,114,000
Collecting societies .	128	48,414,000	23,777,000	150,362,000
		232,416,000	124,111,000	821,476,000

14. *Aggregation of Industrial and Ordinary Life Assurance Statistics*

It is sometimes desired to obtain statistics for the total life assurance business transacted in the United Kingdom by assurance companies and collecting societies. For the premium income this can virtually be done from the data so far reviewed. One assumption has to be made—namely that the "other benefits" of collecting societies can be interpreted as ordinary life assurance. As indicated above in sub-section 13 this assumption is not far from the truth and the error introduced will be small.

For the latest year for which data are available (i.e., 1949, with the qualification concerning accounting periods mentioned earlier) the total life assurance premium income in the United Kingdom can be assembled as follows:

	£
Ordinary life assurance—	
British assurance companies .	166,617,000
Overseas assurance companies .	13,080,000
Collecting societies . . .	3,833,000*
Industrial life assurance—	
British assurance companies .	100,334,000
Collecting societies . . .	23,777,000
Total life assurance premium income	307,641,000

* I.e., "benefits other than industrial" (see text).

It has been explained in sub-section 8 above that it is impossible to ascertain exactly the total funds relating to ordinary life business transacted in the United Kingdom because the published

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funds relate to home and overseas business combined. However, the composition of the total life funds of British assurance companies and collecting societies is given below:

	£
Ordinary life assurance—	
British assurance companies .	1,573,375,000
Collecting societies . . .	26,199,000*
Industrial life assurance—	
British assurance companies .	671,114,000
Collecting societies . . .	150,362,000
Total life funds . . .	2,421,050,000

* I.e., "benefits other than industrial" (see text).

It should be understood that the "life fund" of an assurance company or collecting society represents the actuarial reserves needed to meet contractual liabilities, and does not include any additional reserve funds held as a guarantee against investment depreciation or other contingencies. Consequently the total life funds are somewhat less than the total assets held in respect of life business.

FRIENDLY SOCIETIES, TRADE UNIONS AND SUPERANNUATION FUNDS

15. *Friendly Societies' Statistical Summary*

Information concerning friendly societies is published by the Chief Registrar of Friendly Societies in a *Statistical Summary* similar to that issued in respect of industrial assurance. All institutions registered under the Friendly Societies' Acts 1896–1948 are covered, including the collecting societies which were discussed above in the section on industrial assurance.

The principal classes of friendly society are as follows:

Ordinary friendly societies.
Collecting societies.
Cattle insurance societies.
Benevolent societies.
Working men's clubs.
Specially authorised societies.
Shop clubs.

In 1949 there were 18,893 registered friendly societies, of which 15,968 came within the category designated in the above list as "ordinary friendly societies". This category is further divided between "societies without branches" and "orders and branches". It is characteristic of the "orders" (e.g., Foresters, Oddfellows, Rechabites, etc.) that each branch is registered as a separate society, and in 1949 the 15,968 ordinary friendly societies comprised 14,035 "orders and branches" and 1,933 societies without branches.

The class of insurance which is most usually associated with friendly societies is sickness insurance, under which the benefit normally takes the form of a level weekly payment during sickness. Many societies also provide a death benefit, although this is not one of their major functions. There are, however, other benefits. Among these are pensions or annuities to widows, orphans and old people. Moreover, many societies provide for an annual share-out of a part of the funds, rather in the manner of a slate club.

For societies without branches the *Statistical Summary* provides the following information for 1949:

Number of societies on the register .	1,933
Number of members	5,148,075
Amount paid out in sickness benefit .	£3,324,000
,, ,, in death benefit .	£1,256,000
,, ,, in other benefits .	£8,314,000
Accumulated funds	£144,236,000

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Although "other benefits" account for 64 per cent. of the total benefit payments, no further analysis of this figure is available.

Similar statistics are given for "orders and branches", except that nothing is published for payments under "other benefits". The combined statement for 1949, covering both "orders and branches" and societies without branches, is as follows:

Number of societies on the register .	15,968
Number of members	7,253,388
Amount paid out in sickness benefit .	£5,474,000
,, ,, in death benefit .	£1,840,000
Accumulated funds	£207,691,000

A serious lacuna in these statistics is the absence of any information about contributions received.

The final statement in the *Statistical Summary* combines the membership totals and funds for ordinary friendly societies with those for the other classes of registered society listed above, including the collecting societies which have already been discussed in the section on industrial assurance. This final statement shows that the grand total in 1949 of all funds of registered friendly societies was £398,733,000. This was an increase of more than £12 million over 1948, while the increase for the decennium 1939–49 was £145 million. However, if the collecting societies are excluded, the annual and decennial increases are £1·6 million and £59 million respectively.

16. *Registered Trade Unions' Statistical Summary*

The Chief Registrar of Friendly Societies publishes a *Statistical Summary* from the annual returns of trade unions registered under the Trade Union Acts 1871–1940. This shows the numbers of unions and of members, the items of income and expenditure and the accumulated funds for the past eleven years. For the most recent year of the period the data are subdivided according to industrial group.

In 1949 the insurance benefits paid out were as follows:

	£
Unemployment benefit . . .	159,000
Dispute benefit	74,000
Sickness and accident benefit . .	1,151,000
Funeral benefit	492,000
Superannuation benefit . . .	1,725,000
Other benefits	931,000
	4,532,000

The total accumulated funds at the end of the year were £58,119,000.

17. *Superannuation Funds*

Generally speaking, the trustees of private superannuation and pension funds are not required to furnish returns to any government authority. To this rule there is, however, an exception. In order to escape the provisions of the law against perpetuities the trustees of a fund may, if they wish, register it under the Superannuation and other Trust Funds (Validation) Act, 1927. By so doing they avoid the necessity of periodically reconstituting the trust, but at the same time they incur the obligation of furnishing returns to the Chief Registrar of Friendly Societies.

Such registered superannuation funds are regarded by the Chief Registrar as a type of provident society—a generic term which also embraces friendly societies, trade unions and certain other institutions which, since they are not concerned with insurance, are irrelevant here. Every year a *Registered Provident Societies' General Statistical Summary* is published, and this gives the number and total amount of registered superannuation funds over a period of eleven years. The latest available summary relates to the period 1939–49 and the following data are extracted from it:

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Year	*Number of Registered Funds*	*Total Amount of Registered Funds*
		£
1939	304	89,366,000
1949	417	197,731,000

The above registered superannuation funds should not be confused with certain registered friendly societies which are described as "societies for the provision of annuities and pensions". This latter type of institution, being registered under the Friendly Societies' Acts, is subject to a statutory limitation that no annuity or pension may exceed £104 per annum. Consequently, it is not normally a suitable means for providing superannuation benefits.

It is certain that the number of funds registered under the 1927 Act is a mere fraction of the total number of superannuation funds in the country. Most trustees prefer the legal inconvenience of periodically reconstituting the trust to any invasion of privacy which a statutory obligation to furnish returns would imply.

Nevertheless, the absence of statistics for superannuation funds must be deplored. They are a vital element in institutional saving, and their role in the economic life of the nation is considerable. It is therefore to be hoped that information will ultimately become available concerning the contributions paid, the benefits secured and the total amount of funds held.

ASSOCIATIONS OF UNDERWRITERS

18. *Board of Trade Statements*

Statements of the insurance business transacted by approved associations of underwriters are published by the Board of Trade at the end of the *Summary* which has already been extensively reviewed above in the section relating to assurance companies. There are only two approved associations in existence, viz., Lloyd's and the Association of Underwriters and Insurance Brokers in Glasgow, and each association prepares a series of revenue accounts summarizing the business transacted by all its members. These revenue accounts are reproduced by the Board of Trade in their original form.

Accounts are presented for four classes of business, i.e.:

Life, Motor vehicle, Marine, aviation and transit, Other business.

However, the life business is insignificant, the annual premium income being only £7,000.

A peculiar feature of the returns is a subdivision according to year of account. Thus premiums received and claims paid in 1949 in respect of business underwritten in 1948 are included in the 1948 account. It is intended that the annual returns shall show separate revenue accounts for each of the three most recent accounting years. As 1949 was only the second year for which statutory returns were required, the issue of the *Summary* now under review covers two accounting years only.

For the three classes of insurance other than life, the premium income received by Lloyd's in 1949 in respect of both the 1948 and 1949 accounts was as follows:

	£	£
Motor vehicle—		
1949 account (1st year) . .	4,189,559	
1948 ,, (2nd ,,) . .	267,208	
		4,456,767
Marine, aviation and transit—		
1949 account (1st year) . .	59,580,634	
1948 ,, (2nd ,,) . .	15,411,239	
		74,991,873
Other business—		
1949 account (1st year) . .	54,261,197	
1948 ,, (2nd ,,) . .	17,817,109	
		72,078,306
		151,526,946

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This total is not complete owing to the absence of information concerning the third year of the 1947 account. Nevertheless, it is unlikely that third year premiums are at all considerable.

The activities of the Association of Underwriters and Insurance Brokers in Glasgow are restricted to marine and transit business, and the premium income returned as having been received in 1949 was £37,236.

Other information obtainable from the revenue accounts includes claims, expenses and the "balance" remaining at the end of the year. However, these items are of little value until an account has been closed, since only then is it possible to compare premiums received with claims, expenses and profit.

An odd feature of the accounts is that the amounts shown for claims include "expenses directly incurred in settling claims", so that a clear-cut separation of claims from expenses becomes impossible.

By adding the £151 million shown above as Lloyd's premium income for 1949 to the £371 million given in sub-section 10 for the general insurance business of assurance companies, a total of £522 million is obtained for the non-life premium income of British insurers (other than friendly societies, etc.). This figure is world-wide, and no subdivision is possible between business transacted within and outside the United Kingdom. It is interesting to note, however, that in a statement issued in 1949 the British Insurance Association estimated that 70 per cent. of the fire, accident and marine business of British insurers was transacted overseas.

THE STATE AS INSURER

19. *National Insurance*

The existing National Insurance Scheme came into operation on July 5th, 1948. The National Health Service, which was introduced at the same time, is not a part of National Insurance, although a proportion of the weekly contributions paid by the insured population is transferred to its accounts. Consequently the statistics of National Insurance do not embrace the National Health Service.

Supplementary to the National Insurance Scheme, although a self-contained fund, is the Industrial Injuries Scheme. Separate accounts and statistics are maintained for the two schemes.

Extensive information regarding National Insurance is normally available in the *Annual Abstract of Statistics*. However, the most recent (i.e., 1951) issue of this publication contains virtually no information relating to the existing scheme, although a substantial quantity of data relating to the earlier scheme is available for each year of the period 1938–47 and for the six months 1.i.48–4.vii.48.

For more recent information the following publications may be consulted:

Report of the Ministry of National Insurance for the period November 17th, 1944, to July 4th, 1949.

National Insurance Act, 1946: *First Interim Report by the Government Actuary for the period July 5th, 1948, to March 31st, 1950.*

National Insurance (Industrial Injuries) Act, 1946: *First Interim Report of the Government Actuary for the period July 5th, 1948, to March 31st, 1950.*

The first of these three publications, which includes Industrial Injuries within its scope, contains extensive tables analysing both the numbers of beneficiaries and the amounts paid in benefit according to various frameworks of classification.

The two reports of the Government Actuary are concerned with financial aspects of the schemes. They show that in the year ending March 31st, 1950, contributions received from insured persons and employers in respect of National Insurance were £360 million (after deducting payments transferred to the National Health Service). The corresponding figure for Industrial Injuries was £30 million, making a total contribution income of £390 million for the two schemes.

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Benefits paid during the year were as follows :

	£ *million*	£ *million*
Unemployment benefit	14·4	
Sickness benefit	65·5	
Maternity benefits	8·5	
Widows' benefits	21·3	
Guardian's allowance	·7	
Retirement pension	248·9	
Death grant	1·6	
Total National Insurance benefits		360·9
Industrial Injuries		12·1
		373·0

It is, of course, quite fortuitous that for the year in question the benefits and contributions under the National Insurance scheme should have approximated so closely to one another. In actual fact the contributions received from insured persons and employers are substantially less than the amounts needed to provide the benefits secured and the deficiency is supplied by supplements from the Exchequer.

20. *Government Annuities*

Annuities may be purchased from the Commissioners for the National Debt. Unfortunately, since 1938 no statistics for National Debt annuities appear to have been published. However, it is of interest to note that in the *Financial Accounts of the United Kingdom* for the year 1949–50 an estimated capital liability of £12,581,000 was included in respect of terminable annuities amounting to £1,480,403 per annum.

INSURANCE CONTRIBUTION TO NATIONAL SAVING

21. *Data Available for Measuring Net Saving*

Economists frequently wish to estimate the total contribution made to national saving through the medium of insurance.

Saving through general insurance is relatively small, since premiums collected within a year are largely redistributed in claims, expenses and profits. The chief forms of insurance which operate to promote saving are life assurance and superannuation. However, as already indicated, no information is available concerning the majority of superannuation funds in the country so that estimates of saving through this channel are not feasible.

The amount of saving through life assurance is equivalent to the excess of income over outgo, where income embraces premiums and net interest and where outgo embraces payments to policyholders, expenses and distributed profits. This is equivalent to the increase in total life funds during the year plus any amounts transferred from individual life funds to additional reserve funds.

A difficulty is caused by the limited extent to which data are analysed between business transacted within and outside the United Kingdom. Clearly, in considering the amount of the national income saved through life assurance, it is necessary to include business transacted in the United Kingdom by overseas companies and to exclude business transacted overseas by British companies. Since interest, expenses, profits and funds are not subdivided, it is perhaps best when making these two adjustments to employ the excess of premiums over payments to policyholders.

22. *Estimate of Net Saving through Life Assurance in* 1949.

The Board of Trade *Summary* shows that the net increase during 1949 in the ordinary life funds of British assurance companies was £90 million. An amount of £4 million (net), which is described as "Miscellaneous including transfers to Investment reserve, etc.", is virtually the net result of trans-

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fers to and from additional reserves—as can be ascertained by referring to the published accounts of individual companies. The estimate of net saving may therefore proceed as follows:

	£ *million*
Net increase in life funds of British assurance companies . . .	90
Amounts transferred to additional reserve funds	4
	94
Deduct excess of premiums over payments to policyholders in respect of overseas business of British companies	10
	84
Add excess of premiums over payments to policyholders in respect of U.K. business of overseas companies	3
Estimate of net saving through the ordinary life business of assurance companies	87

To complete the estimate for all life business, the *Industrial Assurance Statistical Summary* must be consulted. Here there is no overseas business to provide any complication. The transfers to additional reserve funds are included in a "Miscellaneous" column. However, reference to companies' accounts shows that out of £10 million shown as miscellaneous expenditure in 1949, more than £7 million represented transfers to additional reserve funds. These figures relate to assurance companies: the corresponding figures for collecting societies are below £1 million.

The estimate of total net saving through life assurance may now continue:

	£ *million*	£ *million*
Net saving through ordinary life business of assurance companies (as above)		87
Net increase in ordinary life funds of Collecting societies .		2
Total net saving through ordinary life assurance . .		89
Net increase in industrial life funds of assurance companies .	31	
Add transfers to additional reserve funds	7	
	38	
Net increase in industrial life funds of collecting societies .	9	
Total net saving through industrial life assurance . . .		47
Total net saving in 1949 through life assurance . .		136

Concluding Remarks

23. *Other Sources*

Some of the statistics referred to in earlier sections may be obtained from alternative sources. Much useful information about insurance is to be found in the *Annual Abstract of Statistics*, and another convenient digest is the *Registered Provident Societies General Statistical Summary*, which has already been mentioned above (sub-section 17).

The statement of statistics issued by the Life Offices' Association and Associated Scottish Life Offices, to which reference was made in sub-section 9, contains information in respect of ordinary life assurance and capital redemption business similar to that provided by the Board of Trade *Summary*. However, the two publications are not entirely comparable, because of differences in the periods to which they relate. An advantage possessed by the statement issued by the Associations is a fuller subdivision of data between assurance and annuities.

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24. *Actuarial Statistics*

The statistics reviewed in this article relate to the volume of business transacted by the various institutions engaged in insurance. However, other classes of statistics emerge as by-products of the business, among which are the mortality statistics assembled and analysed by the Institute of Actuaries and the Faculty of Actuaries. These are collected separately for annuitants and assured lives and are subdivided according to class of policy. Results are published periodically in the *Journal of the Institute of Actuaries* and in the *Transactions of the Faculty of Actuaries* and, by indicating the mortality experienced by particular classes of persons, they provide valuable supplements to the population mortality statistics published by the Registrar-General.

25. *Possible Improvements in Insurance Statistics*

In the course of this article it has been shown how insurance statistics have to be assembled within a framework which is essentially legal. As an illustration it is only necessary to recall that a fund for the provision of pensions and annuities may be constituted as an assurance company, as a friendly society, or as a superannuation fund. If the third course is chosen, the fund may be registered under the 1927 (Validation) Act and so become a registered provident society, or it may remain unregistered should the trustees so decide. Whichever constitution is adopted will determine both the statutory provisions to which the fund will be subject and also the authority to whom official returns of information will be submitted—except that, as has already been pointed out, an unregistered superannuation fund has no liability to furnish returns at all.

Thus the information available is a by-product of government control. The situation is one in which statistics, law and administration are closely locked together, and it provides a salutary reminder that the original definition of statistics was "that branch of political science dealing with the collection, classification and discussion of facts bearing on the condition of a state or community" (*Oxford Shorter English Dictionary*).

In these circumstances it is not altogether surprising if the statistician, pursuing the objects of his science, finds certain shortcomings in the statistical data for British insurance. Unfortunately some of these seem to be unavoidable. The international nature of general insurance, with its re-insurance pools wherein risks from all countries are necessarily amalgamated, renders impracticable any territorial sub-division of statistics and accounts; and this fact effectively inhibits any attempt at a precise statement of the volume of general insurance transacted within the United Kingdom. However, where life assurance is concerned, there seems no reason why the existing subdivision of certain items in the revenue account between United Kingdom and overseas business should not be extended to embrace the life fund itself.

Other items of information which are desirable for a complete survey of British insurance include:

(i) The contribution income of friendly societies
(ii) The funds held in respect of the group pension section of ordinary life assurance.
(iii) The contributions paid, benefits secured and funds held for all private superannuation funds in the country.

So long as these lacunae in the available information continue to exist, any assessment of the relative position of British insurance in the national economy must remain partial and subject to a margin of uncertainty.

26. *Acknowledgment*

The authors would like to take this opportunity of acknowledging the valuable suggestions which, in the earlier stages of this article, they received from Mr. L. H. Longley-Cook, F.I.A.

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International Statistical Institute 27th Session, India, 1951

The 27th Session of the International Statistical Institute was organized in a different way from the 26th Session held in Berne in 1949. It formed part of the *International Statistical Conferences* held at the invitation of the Government of India in New Delhi and Calcutta during December, 1951. Invitations to the Conferences were addressed not only to members of the Institute but to governments and international agencies as well as to international organisations interested in statistics. The total number of participants was about three hundred, of whom about one half were Indian. Of the 150 foreign participants, about 50 were members of the International Statistical Institute.* The latter thus formed a small proportion of the total participants, which is perhaps inevitable when sessions take place in a country far distant from that of most members. The number would probably have been smaller had not facilities for attending the Conferences been generously granted by the Indian Government—chartered planes between London and New Delhi and between Calcutta and London, with intermediate stops at Paris, Rome, etc., being made available for participants.

The agenda of the Conference was a wide one covering, *inter alia*, the appraisal of the accuracy of economic data, and of demographic data, the industrial applications of statistics, national income and wealth, educational and cultural statistics and problems of sampling. Several of the meetings were held in collaboration with the members of other statistical bodies affiliated to the Institute such as the International Union for the Scientific Study of Population, the Econometric Society, and the Biometric Society.

The Conferences were inaugurated in the Parliament House, New Delhi, on December 5th by the President of India (Dr. Prasad), and addresses of welcome were made by the Prime Minister (Mr. Nehru) and the Finance Minister (Mr. Desmukh). A very large number of papers was received—over 150—but unfortunately none of these was available before the opening of the Conferences and many became available only at the last moment. It was not therefore possible to discuss them all, but nevertheless, thanks to the two sessions held simultaneously each morning and afternoon from December 5th to 10th, valuable and instructive discussions took place on all the chief subjects. The second part of the Conferences was held in Calcutta from December 16th to 18th at the fine new buildings of the Indian Statistical Institute. These meetings were devoted principally to problems of sampling. At the end of the Conferences a four-day Seminar was held for the benefit primarily of students of India and from neighbouring countries. The classes were conducted by visiting experts and were well attended. This Seminar formed part of the programme of Statistical Education, inaugurated by the International Statistical Institute in collaboration with U.N.E.S.C.O. in 1949. A Statistical Education Centre has in effect been in operation in Calcutta during 1951, and other centres are contemplated. Professor Allen, the *rapporteur* of the Institute's Committee on Statistical Education, submitted a full report of the Committee's present and proposed activities in this field.

The participants in the Conferences were given full opportunities of studying the statistical work of the Indian Government, and of the Indian Statistical Institute and its Indian National Sample Survey, and a field trip was arranged to an Indian village to see the Survey in operation. Between the two parts of the meeting a special train conveyed, during five days, the participants from New Delhi to Calcutta, visiting *en route* such historic and interesting places as Agra and Benares. The Indian National Committee, which was responsible for the arrangements for this journey as well as for many others in Delhi and neighbourhood, deserves the highest praise for the excellent organization of these excursions, which made known to visitors the wonderful historic past of the country.

The value of Conferences of this nature held in a country which the great majority of foreign participants had not visited before lies perhaps not so much in the papers discussed and the meetings held as in the opportunity to meet statisticians, and to see the statistical work, of a country which for most statisticians it is very difficult to visit, and especially in the opportunity such international conferences give to the statisticians of India and other Asian countries to meet statisticians from countries which they too find it impossible or difficult to visit. One of the most pleasing

* The British participants were relatively numerous: Professor R. G. D. Allen, Mr. H. Campion, Mr. R. F. Fowler, Professor R. A. Fisher, Dr. J. O. Irwin, Professor G. Findlay Shirras, Mr. L. H. C. Tippett, Dr. F. Yates and the present writer, all Fellows of the Royal Statistical Society. Mr. C. A. Moser, also a Fellow, attended as the Executive Officer of the Institute's Statistical Education Committee.

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sides of the Conferences was the large number of statisticians from these Asian countries who attended the meetings, submitted papers, and joined in the discussions. In these respects the International Statistical Conferences of 1951 were an outstanding success. Special thanks are due to Professor Mahalanobis, Director of the Indian Statistical Institute, who as General Secretary of the Conferences was responsible for the preliminary arrangements and the successful organization of the meetings, and to Mrs. Mahalanobis for her generous hospitality in her charming villa in the grounds of the Indian Statistical Institute.

On the "business side" of the Institute's Session, Mr. Rice (U.S.A.) was re-elected President and Professor Allen (U.K.) Treasurer, Dr. Geary (Eire) was elected a Vice-President, Mr. Idenburg (Netherlands) replaces Mr. Tinbergen (Netherlands) as Secretary-General. An invitation from the Italian Government to hold the 28th Session in Rome, probably in 1953, was accepted.

J. W. NIXON.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

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1.—*von Wright* (*G. H.*). A Treatise on Induction and Probability 283

2.—*Villars* (*D. S.*). Statistical Design and Analysis of Experiments for Development Research 285

3.—*Chung* (*J. H.*) & *De Lury* (*D. B.*). Confidence Limits for the Hypergeometric Distribution 286

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9.—*Seltzer* (*L. M.*). The Nature and Tax Treatment of Capital Gains and Losses . 294

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1.—*A Treatise on Induction and Probability*. By G. H. von Wright. London: Routledge, 1951. 310 pp. $8\frac{1}{2}''$. 30*s*.

The theme of this book is fairly summarized on the dust cover: "The present treatise is an attempt to apply the methods of modern symbolic logic to the analysis of inductive reasoning". There are also several excursions into ordinary scientific philosophy.

It is quite fashionable for philosophers to be modest about the attainments of philosophy. Thus the author says disarmingly (p. 12), "I know that the contribution of this book is but a feeble beginning, in need of completion and extension in several directions". On p. 31 he admits that "the problems of discovery and justification will not be further discussed in this book", and he refers the reader to a previous publication dealing with the justification of induction. It should be added further, for the benefit of those Fellows of the Society who have not an exceptionally strong interest in philosophy (and only three Fellows are subscribers to *Mind* according to the latest lists), that there is almost no discussion of Statistics and no reference to "utility".

Chapters I to III define the problems of induction, and explain the logical principles required later. Chapters IV to VI deal with the parts of the logic of induction which are independent of probability. Chapters VII to X give an axiomatic theory of probability and its applications to the logic of induction.

The work as a whole is most painstaking, and if the results are disappointing the author would probably claim that a reasonable clarification of induction in terms of symbolic logic cannot be given in less than 500,000 words. Personally I should not be convinced that the subject had been clarified until a machine had been constructed which was capable of doing our scientific thinking for us.

The rest of this review will be devoted to a description and criticism of several details.

In Chapter I there is much emphasis on the distinction between the activities of discovering and verifying hypotheses, a distinction which is well known to all statisticians and scientists, but which has often been overlooked by professional philosophers.

The definition given for an atomic sentence (pp. 33–4) includes the clause that an atomic sentence is not the negation sentence of another sentence. This can hardly be quite correct, for any sentence is the negation of its negation. It would be better to define an atomic sentence as any sentence belonging to a particular set, S, of sentences, S being *minimal*, i.e., none of its members can be expressed in terms of the others with the help of Sheffers's stroke. Perhaps also S should be *complete*, i.e., *every* sentence should be expressible in terms of the members of S. It is not necessary to assume that S is unique. This definition would be adequate for symbolic purposes though so far no one has produced a useful set, S, of verbally expressed atomic sentences.

On pp. 54–5 a definition is given for the limit of what may be called a *monotonic* sequence of properties or propositions. The definition could be generalized to upper and lower limits of arbitrary sequences, just as in the theory of sets. This generalization would be of theoretical interest, but it is not required for von Wright's purposes.

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Chapters III to V (pp. 63–139) make much use of the "logic of conditions". This part of the book has a very high definition-to-theorem ratio and is not easy reading, as the following passage (p. 117) exemplifies: "The additional eliminative effect exerted by any additional negative instance of H, amounts to the number of initially possible conditioning properties in respect of which the additional negative instance agrees with the given positive instance and differs from *all* the previous negative instances". It is not all as bad as this.

On pages 141–6 it is made clear that induction and definition are not sharply separated activities. The example given may be summarized by saying that phosphorus always melts at 44 degrees, for when it does not, none dare call it phosphorus.

On pp. 138–9 it is argued that Maxwell's Postulate of Spatio-Temporal Irrelevance is purely logical (and Jeffreys is criticized for denying this). If the argument were sound then it would be logically impossible for there to be a fixed point in space which attracted objects towards itself and swallowed them up. The existence of such a fixed point would certainly contradict the principle of relativity and other laws of physics, but it would not contradict logic. The author's argument seems to depend on the fallacious assumption that any peculiarities found at special parts of space must automatically be attributed to the presence of special objects. The whole question is bound up with that of the inseparability of definition and induction. If a suction point were discovered somewhere in space we may not choose to say that there was an object of zero dimensions at the point, the object having unusual properties. We would rather say that Maxwell's postulate was wrong. We would be further encouraged to reject Maxwell's postulate if we found that we could after all measure velocity with respect to the ether and that the suction point was fixed with respect to the ether.

On pp. 136 and 298 reference is made to Keynes' Postulate of Limited Variety. The purpose of this postulate is to make it possible for any law to have a non-zero probability. This purpose would be achieved by a (weaker) Postulate of *Enumerable* Variety. This postulate would follow from the assumption that an unambiguous language can be found in terms of which each possible law of nature can be expressed (in a finite number of words).

On pp. 169 and 219 the author refers to degrees of belief as "notoriously obscure" and cannot see any way of measuring them. He misses the interpretation of the theory of probability as being a method of introducing a certain amount of objectivity into bodies of beliefs. In this interpretation the measuring is done partly subjectively and partly with the help of an axiomatic theory. Presumably the author will have something to say about this interpretation in future publications.

On page 176 a set of six axioms is given with no attempt at justification. In axiom 6 there is a misprint, $\lim(A_n, H)$ should be $\lim(A_n, A)$. This axiom, the axiom of continuity, states in effect that the limit of the probability of a monotonic sequence of propositions is equal to the probability of the limit. It is equivalent to the axiom of complete additivity in the theory of measure. The deduction of the theorems occupies the next forty pages. This could be reduced to ten pages if it were not for the explicit description of elementary logical steps of the type which the mathematician usually takes for granted.

The last paragraph of Chapter VII reveals a further restriction in the field covered: "In this inquiry we shall not make any other claims on behalf of the different interpretations than that two of them, the Frequency Interpretation and the Possibility Interpretation, are valid formal interpretations of our Calculus of Probability. The question of the analysis of probability in the sense of the problem, how we may come to know the truth-value of probability propositions, will not concern us further".

On pp. 245–9 and 297–9 there is a discussion of the Argument from Confirmation. This discussion contains two errors. The initial probability of a law is denoted by p. The probability of the $(n+1)^{\text{th}}$ confirmation, given n previous confirmations, is p_{n+1}. Then the final odds of the law are equal to its initial odds divided by $p_1 p_2 \ldots p_n$. (See, for example, chapter 6 of *Probability and the weighing of evidence*.) Von Wright asserts that the final probability is $p/(p_1 p_2 \ldots p_n)$. This expression is clearly wrong since it could easily exceed 1. It is also asserted that the final probability tends to 1, but this is true only if Πp_n diverges to zero, i.e., if $\Sigma(1 - p_n)$ diverges.

On pp. 64–5 and 254–6 there is a discussion of the Paradox of Confirmation. I would not refer to this triviality if it had not been given a conspicuous place on the dust cover. Consider the law, L, that if a thing has a property H then it always has the property A. The paradox of confirmation is that each case of not H and each case of A is a confirmation of L. The author points out that this paradox is harmless in the sense that these so-called confirmations do not increase the probability of L. This is really a simple consequence of Bayes' theorem.

On pp. 256–64 there is a discussion of the Argument from Simplicity. By this is meant that the initial probability of a law is on the whole greater for simpler laws. The author mentions

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six interpretations, but these do not include (at any rate explicitly) the most important one, stressed by Jeffreys, where the complexity of a law is dependent on the number of parameters in a mathematical function.

Chapter X (pp. 275–303) deals with induction and inverse probability. The main conclusion is that inverse probability is a legitimate part of the Calculus of Probability but may not be useful in practice. Personally I think that inverse probability is indispensable in practice if only in order to provide a reasonable philosophical justification for the methods of those who think they reject it. Another application of inverse probability is to render immediately obvious that the likelihood ratio (in the sense of Wald rather than Wilks) exhausts all the information in an experiment. This is clear from the interpretation of the likelihood as the factor in favour of a hypothesis, i.e., as the factor on the initial odds producing the final odds. Inverse probability is also used in the theory of communication and by Woodward and Davies in the theory of radar information. In fact any problem which can be tackled by Fisherian methods can in principle be tackled by inverse probability, though not conversely. The answers may not be precise, but that cannot be helped.

Philosophy, as a university subject, is largely the history of philosophy, and von Wright has a remarkably good grasp of the history of the philosophy of probability up to about 1935 (see pp. 290–303). The index of names refers to 85 people, of whom at most 13 are living.

Judging by his great devotion to probability, it seems likely that the author's future publications will contain important advances on the present book. Meanwhile most of us will continue to use an axiomatic theory for the purpose of improving our bodies of beliefs. I. J. Good.

2.—*Statistical Design and Analysis of Experiments for Development Research.* By D. S. Villars. Dubuque, Iowa: Wm. C. Brown Co. 1951. xvii + 455 pp. 8¼″. $6.50.

This mimeographed book deals in 14 chapters with the usual topics of mathematical statistics, such as tests of significance, analysis of variance and covariance, design of experiments, estimation, control charts, and even some sequential analysis. The illustrations are mainly taken from the chemical industry, and this may be advanced as a justification for publishing another book on those traditional lines. Some merit may be claimed, moreover, for the author's bright and breezy style, but the reviewer doubts that this is altogether an asset. It is stated, on p. vii of the Introduction, that "a journalistic order of presentation is used", which implies that "it will be necessary to use terminology which we will not yet have had an opportunity to define". The alleged advantage of this method is "that one may almost immediately start applying variance analysis to his own data". Later chapters "will give refinements and elucidate the fundamental theoretical principles", but in the meantime the reader is asked to be patient, or to consult the glossary at the end of the book. In spite of his presumed hurry to get on with the analysis, he is encouraged to carry on reading as well, for the purpose of "satiating curiosity", and also to counteract "an impression at one time held in many statistical quarters that Fisher's methods are empirical only and not based on mathematical distributions".

The obvious disadvantages of allowing a statistician to use methods which he does not understand need hardly be emphasized, but the reason given for studying the underlying theory is strangely incongruous. There is also a tendency to oversimplify half-truths, once more reminiscent of journalism. Thus we are told on p. 3 that large sample statistics "has reached a high degree of development in America, principally as a result of the work of Shewhart . . ., Wilks . . ., and Wald . . . Small sample statistics was developed in England by R. A. Fisher and his school". To give one more example, we learn on p. 159 that the term regression "is generally used almost interchangeably with 'correlation' ".

In those sections dealing with practical problems the descriptions are competent enough, but the logic is occasionally at fault. For example, on p. 55 it is remarked, rather unfairly, that the reference to type II errors in the Neyman-Pearson theory "implies that one always accepts the null hypothesis whenever he fails to disprove it". The astonishing remedy is as follows: "We avoid making a type II error by abstaining from accepting null hypotheses uncontradicted by the data". In a similar vein, it is stated on p. 39 that fiducial limits rather than confidence limits are used, because "it seems a little more concrete to be able to assign a 'probability' to a definite range of possible values". Here the author has overlooked the fact that the logical possibility of such assignment has given rise to some of the most profound analysis in statistics, and can certainly not be settled by the choice of a definition.

The theory of testing hypotheses contains further pitfalls. It is not generally true that the critical region "is that in which the data would have most likely fallen had the null hypothesis been untrue" (p. 54), or that, if the observation falls into the critical region, the probability that the null hypothesis is untrue equals the significance level (as implied on top of p. 56). The state-

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ment on p. 49, implying that $\bar{x} - \mu$ is distributed as chi-squared with one degree of freedom is probably due to a misprint in a generally careful edition.

The reviewer cannot help saying, in conclusion, that he has not found any reason for recommending the acquisition of the book for private libraries in this country. One might, however, occasionally consult it for the many examples and the problems (with solutions) contained in it. Tables are given for t, chi-squared, F and d, as are various designs of experiments.

S. VAJDA.

3.—*Confidence Limits for the Hypergeometric Distribution.* By J. H. Chung and D. B. DeLury. University of Toronto Press, for Ontario Research Foundation. 1950. (London, Oxford Univ. Press.) xiii + 144 pp. $12\frac{1}{4}''$. 17*s*.

The hypergeometric distribution may be defined by the formula

$$P_x = \binom{N}{n}\binom{X-x}{x-x}\Big/\binom{N}{n}.$$

This book provides charts from which may be obtained confidence limits for X/N (or X) based on observed values of x/n (or x). Charts for X/N against x/n are given for all combinations of

(*a*) confidence coefficients 90 per cent., 95 per cent. and 99 per cent.;
(*b*) sampling rates ($s = n/N$) 5–10 (10) 90 per cent.;
(*c*) population sizes (N) 500, 2,500 and 10,000.

Charts for X against x are given $s = 5$ per cent. and $N = 500$, 2,500 and 10,000, but for $s = 10$ (10) 90 per cent. only the cases $N = 500$ and $N = 10{,}000$ are covered. A scheme for interpolating for other values of s and N is described.

The charts are easy to read and are printed on tough paper which should stand up to hard wear. It is unfortunate that the pages are not numbered so that it is a little troublesome to find the particular chart required. The regular user of the book will doubtless construct his own index; the occasional user will find the lack of pagination quite a nuisance.

N. L. JOHNSON.

4.—*Hospital Morbidity Statistics.* By Donald Mackay, General Register Office. (*Studies on Medical and Population Subjects, No.* 4.) H.M.S.O., 1951. 113 pp. $9\frac{1}{2}''$. 3*s*. 6*d*.

Sickness is to a degree curable and to a degree preventable, and the national resources are continually being drawn upon and deployed to meet these needs.

Efficient organization of health services must be based upon adequate fact-finding We need to know the incidence of diseases, the nature of their causation, the essential therapeutic requirements of and durations of treatment, the sections of the population affected and the secular and seasonal trends. The overall incidence of disease can only be measured given adequate and practical criteria for defining departure from normality. The smaller the departure from normality, i.e., the greater the extent to which minor ailments are to be included, the more difficult is the enumeration; since so much fails to come to the attention of those qualified to diagnose. Up to the present time society has contented itself with collecting detailed statistics of two more narrowly defined groups of diseases, those which kill and appear on death certificates, and those which constitute a threat to the community by contagion viz. infectious disease notifications. Interest has, however, been taken from time to time in another sharply defined and, therefore, more easily enumerated group, namely, the diseases treated in hospitals Multiplicity of governing bodies were an obstacle and the beginnings of tabulation of diseases in hospitals were made only in the large coherent bodies, an early and shortlived attempt in London poor law hospitals, and later a more sustained effort by some of the municipal authorities when they became hospital authorities by inheritance of poor law hospitals in 1930 and by the expansion of a municipal hospital service thereafter. In the early thirties, when medical records were less easy to summarize than now, Glasgow, Manchester and London and others were routinely tabulating summaries of case-histories of patients treated in their hospitals. They produced their own morbidity codes, which were inadequate, but which in those days were no mean achievement. In London (Spear and Gould, 1937) the treatments in 77 hospitals were annually analysed from 1930, using punched card machinery. Finally the General Register office, building upon this experience and taking the opportunity afforded by the unifying authority of the National Health Service, introduced a national hospital discharge study. Selected hospitals were invited to complete summary forms

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for every discharge. These forms contained information of sex, age, diagnosis, duration of stay and outcome, and this information was translated into punched cards.

This first Report of the working of the "National Morbidity Enquiry" of the General Register Office covers the first six months of 1949. The lag in publication is fairly long, but it is understandable having regard to the inevitable difficulties of initiating a scheme of reporting of this kind.

Dr. Mackay begins with a fascinating historical survey: "The present Enquiry does no more than take to its logical conclusion the 'Plan for Hospital Reports' contributed in 1837 by Dr. Cowan". "The young and flourishing Statistical Society . . . proceeded in the year 1840 to appoint a Committee on hospital statistics . . .", with Farr playing a leading role. In 1860 Florence Nightingale renewed the plea for hospital statistics. But the proposal became practical only in the era of punched cards.

Dr. Mackay devotes a chapter to the value of hospital in-patient statistics at the present time. As he says, "from no other group of morbidity statistics can so much precision and detail in diagnosis be expected, and greater opportunities are afforded in hospital than elsewhere for the careful recording of information descriptive of the patient's social and economic circumstances. Much that is valuable both to clinical practice and to social medicine may therefore be learned by examining the proportionate incidence of admissions relating to particular diseases when grouped by age, sex, civil state and occupation". Some rather broad assumptions are made. After admitting that, apart from differential accommodation, differential morbidity, differential rates of disposal and recruitment from the waiting list may affect the sex distribution of the statistics, the author says: "These may be serious limitations to the value of proportionate morbidity studies in any one hospital, but over a region, and especially over the country as a whole, they tend to cancel themselves out; and it may be assumed with some confidence that, generally speaking, the bed accommodation as between the sexes is in accordance with the demands made upon it". No evidence, however, is given to justify this confidence, though the waiting list figures and other statistics are analysed from the annual returns rendered by hospitals to the Ministry of Health, and are available to the General Register Office.

Discussing measures of length of in-patient treatment the report says: "Much work remains to be done before a satisfactory index of occupancy based on the average stay for a particular condition can be obtained. There is a wide range of variation even in the commonest diseases, and the stay in hospital is not "normally" distributed in all instances: it may be that the median, with appropriate measures of dispersion, will be found more satisfactory as a summarizing index than the mean, which is often unduly weighted by the small number of cases which develop unusual complications and require prolonged treatment in hospital". It might be suggested that the "mode" should be considered. The median is, after all, only the duration, which happens to be exceeded as often as it is not. Clinicians really want to know the most likely duration; this is precisely what the mode is. The following distribution statistics were typical of municipal hospitals before the war, when there was a heavy loading of long-stay chronic sick cases, even after most had been weeded out and transferred to *ad hoc* chronic sick hospitals. For all treatments completed in L.C.C. general hospitals in 1937 the mean was 28·6, the median 17·0, and the mode 13·7. These figures are for all diseases combined. What is more important, however, than wrangling over the choice of statistics is Dr. Mackay's chief point that "national and regional hospital morbidity statistics can provide average values for particular diseases at different ages against which individual hospitals can measure their own experience".

A further and most valuable aspect of hospital statistics lies in the fact that "the diagnostic picture of hospitalized disease will vary from year to year in accordance with changes in medical practice", and knowledge of the prevailing trends will be valuable in the planning of new hospitals and in the utilisation of existing accommodation. The point is well made.

Dr. Mackay goes on to suggest that routine collection of in-patient statistics will encourage that degree of precision in documentation which will facilitate other forms of research. We hope they will; for the domestic uses of hospital records in indicating differential prognoses, the efficacy of various forms of treatment, and, indeed, the efficiency of medical work generally, need to be stressed. As Dr. McKinlay (1949) has said, "the main contributions of hospital information to the general requirements of a morbidity programme are quite other than as indicators of sickness prevalence. Initially, at least, we should look to them for knowledge, primarily, of the effects of therapy, the relative merits of the varying treatments at present in use with a view to choosing the best, and to provide the necessary and adequate background of data for the speedy assessment of any new methods which may be introduced".

The hospitals contributing in 1949 were not a representative sample though they included all patients. In discussing representation Dr. Mackay makes rather too much of the difficulties of sampling. He admits it is economical, but does not trust individual hospitals to draw a random

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selection. Modern hospitals are, however, rather careful about the numbering of their patients, and may be relied upon to select in the series of discharges, patients whose number for example has a particular digital ending. It will certainly make the in-patient survey less formidable, enable tabulations to be carried out more rapidly, besides lessening the clerical load of hospitals, if an efficient system of sampling can be contrived.

With regard to occupation, the Report says: "A differential incidence of a particular disease within the five social classes implies no more than the likelihood that one or more factors in the environment may be found to be of importance in its aetiology. Different factors may be responsible in different cases. Special studies will usually be necessary to distinguish between them, and to ensure that the explanation does not, perhaps, lie in different likelihoods of admission to hospital". In other words, there is no exposed-to-risk. We do not know how many people engaged in occupation A would be admitted to hospital if they suffered from disease B, except for diseases like poliomyelitis which are totally hospitalized. It is doubtful whether the routine collection of occupation data is really justifiable. To attain precision will make it the most exacting item to be completed on the in-patient form. The intrusion of the concept of social medicine into the clinic, however, makes the social environment important in relation to the individual patient, and so a minimum of information ought to be in the medical record. If an effort can be made for the one purpose, it is difficult to say that it cannot be made for the other.

The discussion of the reporting of diagnoses is an attractively written and very sound section of the Report; we take exception to only one comment: "Lastly, the frequency with which diagnoses in III and IV occur in association with particular conditions in I may be tabulated. Such diagnoses are those which the doctor responsible for the case does not believe, or has not proved, to be causally associated with the primary cause of admission. Unexpectedly high frequencies of association shown by the tabulations will, therefore, be of considerable interest to students of aetiology and of the art of differential diagnosis". We accept the point about differential diagnosis, but we are more doubtful about the contribution to aetiology, for here there may be statistical fallacies which have been emphasized by Berkson (1946).

The trial tabulations are interesting. For the first time we have a real measure of the contemporary difference in the quality of material handled at teaching as opposed to non-teaching hospitals. It will be interesting to see whether these differences will narrow under the new regime Dr. Mackay follows the present General Register Office practice of dealing with diseases within age-groups rather than with age-groups within diseases. This may be useful from the point of view of hospital administration, but it is not easy to get a whole picture of one disease. The statistics of burns and scalds illustrate the difference between the incidence and the hospital admission rate ; a condition which is lightly regarded in an adult may necessitate the hospital admission of a baby. There are conditions, too, which may be exaggerated in relative importance by a high readmission rate. The Report refers to strabismus in this connection. Some measure is given of the high incidence of hernia in male infants, and it is surprising to find that hernia was never less frequent than 2 in 100 admissions at any age. At ages 15 to 44 it is of interest that peptic ulcer heads the list for males, but is well down the list for females, even when obstetric conditions are excluded. "At ages 15 to 44 acute pharyngitis and tonsilitis caused admission twice as frequently among women as among men; 255 discharges as compared with 127. While at all ages there was an excess of males for respiratory infections in general, more women than men in this particular age-group were admitted with acute upper respiratory infection, influenza, enlarged tonsils and adenoids, as well as with acute sore throat. The most obvious explanation, and probably the correct one, is that the female excess arose from admissions of nursing staff . . . but there are other possible explanations; for example, when the breadwinner is incapacitated with a severe upper respiratory infection his wife can nurse him, but if she is similarly affected there may be greater justification for her admission to hospital". In the absence of populations at risk, these conclusions are, to say the least, speculative, though Dr. Mackay is clearly right to discuss them. More sure, and no less interesting, is the conclusion that coronary heart disease has an earlier age incidence in men than in women. The higher incidence of gall-bladder conditions in women is noteworthy.

There are many interesting features in the figures, but it is clearly not intended that any statistical conclusions should be drawn from the Report. One omission which we would like to see remedied in future Reports is the consideration of the extent to which the hospital data add to or contrast with the picture given by mortality statistics. The impression one gets is that, in general, the picture is very similar, but more detailed study might reveal surprising differences. In the present Report Dr. Mackay is in the main setting out to show what can be done, and how much better it can be done, when the system is well installed, and there is a universally high standard of record keeping and co-operation. There is no doubt that the General Register Office will make the analysis of hospital diagnoses as excellent as its internationally respected analyses of

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death certificates. It augurs well for this project that Dr. Mackay, in the tradition of William Farr, approaches the subject with such obvious concern for fundamentals.

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B. BENJAMIN.

5.—*La Recente Inversione nella Tendenza della Natalità.* By Bernardo Colombo. Padua: Cedam, 1951. viii + 183 pp. 10″. 1500 l.

When, after 1933, the birth rate in Great Britain ceased to fall and a similar development was observed in other countries, demographers were faced with two problems of considerable importance. At the end, for the time being at least, of the decline was the population reproducing itself? Why did the birth-rate cease to fall? As is evident from the researches of the Royal Commission on Population, the first question cannot be answered without an investigation of the second.

A close study of the data for one country alone can throw much light on the subject, but international comparisons should be capable of adding valuable further knowledge provided that the customary difficulties can be overcome. In undertaking the task of examining the fertility statistics of several countries comprehensively the author has done an important service, and has produced a work deserving the attention of all who are concerned with the analysis of population movement. He has brought together a larger range of data than can be found in the Demographic Yearbook of the United Nations Organization and has shown many of their principal features, analysed progressively in a series of comparative tables. This is an essentially practical inquiry, free from the abstract theorizing which is often a temptation to demographers.

A few of the tables exhibit statistics for as many as eighteen countries, but most of the numerical illustrations relate to a dozen or less. They are drawn in the main from the British Commonwealth, from Europe and Scandinavia, but the U.S.A. is also included. At first sight it is surprising that the author's own country, Italy, is not represented at all; the analysis has been restricted, however, to series of birth-rates showing a reversal of trend from decline to recovery, and there are many countries that do not qualify for inclusion. Such a limitation of scope is perfectly reasonable, and in many respects an advantage, so long as the existence of the excluded group of nations is remembered when drawing the final conclusions from the inquiry.

After the principal items of information about the general trend of fertility in the selected countries during the last thirty years or so have been enumerated, certain conclusions are drawn, namely that there is a uniformity in the change in trend, that it is contemporary and that it is progressive. In seeking to find basic similarities in all the diversity of figures the author is perhaps justified in drawing these conclusions, but the reader cannot but be impressed by the differences as well as the agreements, for instance in the greatly varying size of the recovery.

The effects of changes in the distribution of the population with regard to age and sex, in the numbers of illegitimate children and in divorces are considered, and it is shown without difficulty that such factors can have had little influence on the general movement of the birth-rate. In some countries they have contributed to the trend, in others they have operated against it.

Variations in marriage age are next examined. After finding that the average age at marriage has altered only to a small extent in recent years, the author tends to dismiss the complications depending on marriage age, and to concentrate upon the total number of marriages each year and their product. It is somewhat disappointing that no attention was devoted to the dispersions about the average marriage age, for these may change in such a way as to affect fertility without having a material influence on the average age at marriage.

In order to measure the numbers of births at the various marriage durations against a suitable exposed to risk, recourse was had to the device of using the relevant number of marriages without any allowance for deaths, divorces or temporary separations of marriage partners. This seems unavoidable, although unsatisfactory—particularly in time of war. A more serious defect, that could have been eliminated, is the grouping of the data according to year of birth occurrence rather than by year of marriage. In spite of this, however, the conclusion drawn by the author that changes in the annual numbers of marriages are only partly responsible for the general trend of fertility seems reasonable. At the same time, although a more detailed investigation by age at marriage would have been cumbersome if extended to all countries, some limited examination of this aspect would have been desirable.

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In this connection, it is of interest to compare the data given in the book in respect of England and Wales with those made available in the publications of the General Register Office. Such a comparison shows that the full potentialities of the fertility statistics of this country have not been exhausted by the author; in an international survey, however, such a complete treatment could not reasonably be expected.

The analysis of recent fertility changes has been carried to its furthest stage in a series of tables showing the numbers of children per married couple according to the three characteristics, year of marriage, marriage duration and birth-order, in combination. Here again the form in which the data are set out, with its emphasis on secular changes rather than the experience of generations, is open to criticism, but it is often possible to envisage how the figures would look if re-arranged into the desired order. An important limitation is that the number of countries supplying data is reduced to five, only one of which affords a really comprehensive series of figures over the whole of the period of time during which the essential changes have been taking place.

The post-war developments in fertility were, it is suggested, affected by the making up to strength of families whose building was postponed during the war, and attention has therefore been concentrated on the years 1941–45. The author traces from the data for these years signs of a greater desire to increase the family among married persons who, at a given marriage duration, had relatively few children. Further, he deduces from reports on differential fertility collected from various countries that there was a higher increase in fertility in those zones, social classes and groups of families which in the past exercised a more extensive control over births.

In his final summing up the author discounts economic effects and sees, with Gini, the recovery in fertility as a reaction of an instinctive nature that the reality of total war let loose, and a "triumph of the instincts . . . over hedonistic reasoning". These final remarks may well leave the reader unconvinced, especially if he has noticed that the turning-point came in some instances before the war, and that in many of the countries most affected by the war there is either no turning-point or a smaller one than in neutral countries. Nevertheless, there is much of interest in this book.

P. R. Cox.

6.—*Social Surveys and Social Action.* By M. Abrams. London: Heinemann, 1951. [4] + 153 pp. 7¼″. 8*s.* 6*d.*

This book, which has been written for the Contemporary Science Series, describes the developments that have led to the modern social survey. The author is mainly concerned with surveys providing facts on which it is possible to base a policy of social improvement. In the early chapters he shows how, up to the late nineteenth century, general beliefs and opinion made social surveys in the modern sense quite unthinkable, but that this situation gradually changed until, when the full efforts of the Industrial Revolution became apparent, surveys investigating the poverty of the people were inevitable. For the benefit of those readers unfamiliar with social surveys, a particular inquiry (that of the Bournville Village Trust, 1938/39) is described.

The main theme forms the subject of the third, fourth and fifth chapters, which include an account of the pioneer work of Booth, Rowntree and Bowley. For the next two chapters this line of thought is interrupted to deal with two applications of the technique—Market Research and Public Opinion surveys. The main theme is resumed in the eighth chapter, which describes developments in Britain since 1934. After a short chapter on the U.S.A., the book ends with a discussion of the potential value of surveys in a Welfare State.

Recent developments will naturally be of immediate interest. It is somewhat unfortunate, therefore, that the chapter on developments since 1939 is not as comprehensive as one would wish. The reader is prepared for omissions by an introductory paragraph which explains that it is impossible to deal with all developments over the decade and that only some of the most important can be briefly described. But there is no guide as to the relative importance of the subjects selected and the layout of the chapter will not assist the reader in forming his own judgment. Thus in the first three sections of this chapter surveys into food consumption and nutrition, old age and town planning are discussed. The importance of these three subjects will not be denied, but there are nevertheless many other fields of research in which surveys have been used to great advantage and which are of sufficient importance to justify separate sections.

Similar criticism can be levelled at the second set of three sections, in which other fields of research are briefly covered by taking three organizations and explaining the kind of work each has done. The three are "Government and Surveys", "Social Surveys Specialists" and "Mass Observations". No mention, however, is made of the greatly increased interest shown in recent years by Universities. This is rather surprising in view of the disproportionate amount of space given to "Mass Observation" as compared with other sections. The section headed "Government and Surveys" is by no means comprehensive. As an example of an omission, there was the

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inquiry into clothing purchases under rationing conducted for many years on behalf of the Board of Trade by a well known Market Research Agency. The Ministry of Labour Cost of Living inquiry in 1937/38 is given only a single sentence. The economic and political importance of the cost of living, the interim retail price indices and the decision to hold a new inquiry would surely justify some more detailed statement. Incidentally, there appears to be no reference to the companion middle-class survey carried out by Massey. The way in which this chapter has been divided up may also help to explain why the Food Survey carried out by the Ministry of Food is dealt with separately in the first section and not in the section dealing with Government surveys.

Finally, the treatment of market research is disappointing. The author is such a well known exponent in this field that one could have hoped for some details on the growth and present importance of market research in the economic life of the country. As it is, the chapter on market research compares unfavourably with that on public opinion surveys. Only two paragraphs in the chapter are concerned with this aspect of the subject, while the remainder of the nine pages include a description of the kind of questions and subjects on which market research can provide useful information, and a discussion on quota sampling.

This is a readable book, mainly written for laymen. For those unfamiliar with the subject it will provide some of the background needed to appreciate the significance of social surveys. Most statisticians, however, working in this field should already be acquainted with the material presented here.

W. F. F. KEMSLEY.

7.—*What Happens during Business Cycles: A Progress Report.* By Wesley C. Mitchell. New York: National Bureau of Economic and Social Research, 1951. xxxi + 386 pp. 9″. $5.

According to the plan of the National Bureau's business cycle research programme as it was originally conceived, publication of results was to take place in three stages: first was to come an introductory volume of a primarily methodological character; second a series of monographs dealing with particular aspects of business cycles; and finally, to mark the culmination of the whole project, a general treatise was to draw together and synthesize the conclusions reached in the monographs. The present volume, edited by A. F. Burns and published three years after Mitchell's death, is not that general treatise, the appearance of which lies presumably still in the fairly distant future. *What Happens during Business Cycles* is a preliminary summary of findings which Mitchell decided to undertake when it became evident that the completion of the entire programme was likely to take many more years than was at first contemplated. The provisional character of the present work no less than its incompleteness—only three of the seven parts of the book which Mitchell had planned had been prepared at the time of his death—requires continually to be borne in mind; it is not to be regarded as the National Bureau's last word on business cycles. But neither on the other hand is it a mere summary of already familiar results. In his interesting introduction, Mr. Burns writes (p. xi): "No existing publication elucidates so fully or so authoritatively what happens during business cycles as Mitchell's fragment"; and in certain respects at least this claim may be upheld.

The statistical foundation on which the book is based consists of the "reference-cycle patterns" of a very large number of time-series relating to the United States economy. (In contrast to Mitchell's 1927 volume, *Business Cycles: The Problem and its Setting*, no series for countries other than the United States are discussed.) The statistical techniques by which these reference-cycle patterns are arrived at are familiar from previous National Bureau publications, and were expounded at length in Burns and Mitchell's *Measuring Business Cycles* (1946). Reference dates are first established for peaks and troughs in general business activity. Each series is broken up into reference-cycle segments on the basis of these reference dates, and the seasonally-adjusted data within each segment are expressed in terms of "cycle relatives", i.e., as percentages of their average value over the given reference-cycle. Each reference-cycle is then divided into nine stages, and an average is computed of the cycle relatives in the different reference-cycles at each of these stages. The result gives the reference-cycle pattern. It may be observed that little use is made in the present work of the "specific cycle" measures to which so much space was devoted in *Measuring Business Cycles*.

The book is divided into three parts, and throughout all of them Mitchell's scholarly care in exposition and urbanity of style cannot fail to impress the reader. After the technique of analysis has been briefly explained in Part I, Part II, which comprises the bulk of the book, is devoted to a discussion of the varieties of cyclical behaviour as revealed by the reference-cycle patterns of the different series. These patterns are analysed in terms of their timing (leads or lags in comparison with reference-cycle turning-points), conformity (consistency with which rise or fall in the series is related to reference-cycle expansion or contraction), amplitude and cycle-by-cycle variability. The chapters dealing with conformity and variability are largely taken up with

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technical problems of measurement and bias, particularly those arising out of the treatment of trend implied by the National Bureau measures, and are of less interest to the economist than the chapters on timing and amplitude. Part III on the consensus of cyclical behaviour (not fully completed) analyses the reference-cycle patterns of a group of "comprehensive" series on lines similar to those used in Part II for the analysis of the full sample of series, but with more emphasis on the general shape of cyclical movement emerging from comparison of the series. The second volume was planned to give an overall view of the cycle stage by stage.

The reader in search of simple and memorable generalizations about the causes of the trade cycle and the means by which it may be controlled will not carry away much from the perusal of Mitchell's work. Even such a reader, however, cannot fail to be interested in the asymmetries which Mitchell finds in the shape of a typical cycle. Sine curves are shown to be a quite incorrect delineation of the norm. Growth is most rapid in the *first* stage of the upswing, though in contrast the fall in the first stage of the recession is commonly rather milder than in the ensuing stage. Retardation of the rate of decline is very pronounced in the last stage of the contraction, but the retardation in the rate of growth in the concluding stage of the expansion is a good deal less marked.

Generalizations of this type, however, do not figure very prominently in the book, and its greatest value is to be found in the behaviour patterns manifested by the individual series. These series range from those showing the price of potatoes and orders for oak flooring to such comprehensive measures as the volume of industrial production and gross national product—though the latter, being, like other similar series, available on an annual basis only, does not lend itself very readily to analysis by the National Bureau technique. This collection of series provides an invaluable fund of material, and should form an admirable corrective to loose and unquantified thinking about the cyclical process.

There is, however, one doubt that may be voiced about the interpretation to be given to the reference-cycle patterns. In conformity with the National Bureau's famous definition, according to which "in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own" (p. 6), the cycles marked off by the reference dates are of very diverse nature and duration. Thus the average behaviour of any series in contraction is obtained by averaging such contrasted instances as the 14-month contraction of 1926–27 and the 45-month contraction of 1929–33—the length of each of the stages VI, VII and VIII (of the nine stages into which the cycle is divided) being little more than three months in the first instance and over a year in the second. One cannot help wondering whether many of the results might not have come out quite differently if, for example, the period 1921–29 had been treated as a single expansion instead of as two-and-a-half complete cycles. In a good many cases, of course, the distinction between major and minor cycles is inapplicable or difficult to make; but for the inter-war period at least it has a fairly clear significance. This is the more important, since so many of the series analysed relate only to the inter-war period. One would welcome more explicit discussion and reassurance on this point in subsequent National Bureau publications.

What Happens during Business Cycles contains no theory of the cycle in the sense in which that term is commonly understood. One may perhaps doubt whether any such would have been forthcoming even if Mitchell had lived to complete his book. But if there is no theory, there is certainly a characteristic approach. Mitchell himself summarizes it in the Marshallian phrase, "the many in the one, the one in the many", and he never tires of stressing the diversity and complexity of economic processes, notwithstanding their common conformity to business cycles. Indeed the impression left with the reviewer is that the main value of the National Bureau's business cycle researches is likely to be found in the analysis of particular aspects of the cycle and of the cyclical patterns found in particular sectors of the economy rather than in any more general formulation that may ultimately be arrived at. Time and again in *What Happens during Business Cycles* the reader's attention is arrested by the behaviour of some series which he feels can be properly elucidated only by a much fuller consideration of all the related evidence, both quantitative and qualitative. So it is with the series on interest rates and banking, on different aspects of the investment process, on production and prices of particular categories of goods, and so on. Often Mitchell briefly puts forward explanations for the peculiarities observed, but these explanations, suggestive as they may be, are necessarily sketchy and incomplete in the space available. Already a number of valuable books and papers on special aspects of the cycle have been published by the National Bureau, and further instalments are promised. The monograph rather than the general treatise is evidently the appropriate place for such studies. Until more of these monographs, initiated under his inspiration, have been completed, it will be too soon to make a final assessment of Wesley Mitchell's contribution to our knowledge of business cycles.

R. C. O. MATTHEWS.

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8.—*Conference on Research in Income and Wealth: Studies in Income and Wealth*, Vol. 13. New York: National Bureau of Economic and Social Research, 1951. xiv + 587 pp. 9". $6.00.

This substantial volume is a record of the proceedings at the meeting in April, 1949, of the Conference on Research in Income and Wealth. All the ten papers that it contains deal with one aspect or another of the distribution of income in the United States of America. It is a book for the specialist rather than for the general economic statistician with some curiosity about income distribution, and it is more suited to reference than to cover-to-cover reading. It is a pity that, although a good index is provided, there are no summaries given of the content of the somewhat lengthy articles. The potential reader may thus be alarmed at the amount of his home-work, and consequently be discouraged from learning much that would be to his advantage.

A large proportion of the text concerns itself, not unnaturally, with the details of income statistics at present available in the United States. These particulars are not, of themselves, of great general interest to statisticians resident elsewhere. What are of importance to this class of reader are the lessons learned by American statisticians, in close contact with an extensive array of statistics of income distributions, of a variety quite unknown elsewhere, and able to gain valuable experience in their detailed analyses. A perusal of the ten papers makes it at once clear that there is no general agreement among American statisticians about the moral of these lessons for future research.

In a thoroughly painstaking cross-check of the various sources of information available, Mrs. Selma Goldsmith shows up in startling relief the deficiencies in the results of sample inquiries into the distribution of income. Not only do the subjects of such inquiries generally understate the total income that they receive, but also the probable degree of understatement varies widely according to the source from which the income came. The evidence assembled suggests quite strongly that declared receipts of dividends and interest given to investigators (not employed by the Bureau of Internal Revenue) amount, at best, to about 25 per cent. of the sums actually received. Other contributors stress the fact that the tendency to understate is especially strong at both extremities of the income distribution. At the upper end of the distribution the strength of the bias is quite understandable, but apparently the casual earnings of people at the bottom often get left out as well.

The investigation of farm income by Nathan Koffsky and Jeanne Lear reveal that a surprisingly large number of persons derive a negative income from their agricultural activities. All adjustments made for the overstatement of expenses and the under-declaration of receipts, coupled with the reminder that some business and professional men farm for fun and not for sheer gain, fail to convince even the not very cynical reader that all is really well with the basic data.

All the researchers were clearly unhappy about the reliability of the figures that they presented. But on the question of the desirable future action the conference was not of one mind. One large group, probably well entrenched in this particular field, appeared to think that the collection of more and more figures was the paramount need. Definitions of income and of its recipients should be standardized, more questions of greater complexity should be asked of the surveys' victims, and somehow survey procedure should be tightened up until it is possible to bludgeon liars into telling the truth and to convert hazy memories into perfect recollection. Only in this way will there be made available a general purpose distribution of income of sound character, which can be employed, without second thoughts, in all the manifold and devious ways in which such objects are used.

A more closely reasoned view was put forward in Mrs. Dorothy Brady's excellent article on "Research on the size distribution of income". Her attitude found support in the pithy comments of Milton Friedman and, in connection with another paper, of Harold Barger.

All three were bold enough, in effect, to question the nearly obsessional preoccupation with the distribution of income itself, to the exclusion of the purposes to which it was to be put. Can there be a "standard" distribution of income, which will answer every question asked of it? Why should a particular one-way classification of "spending units" by size of total income be sought with the same ardour, as if it were the philosopher's stone? Does such a strange aggregation mean so very much in a vast area with wide differences in price from place to place, or over a period of time, in which "spending units" change their composition under social and economic pressure?

The need is not for more sources of data, but for more time to be spent on an enlightened analysis of what exists already. Estimation, adjustment, imputation and unrestrained manipulation should give way to the painful business of thought. The information already available should be made to yield all its secrets, and, if possible, to contribute to a fuller understanding of the determinants of a complicated multi-dimensional income structure. Hypotheses should

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be formulated about the way in which family and other income is determined, and then tested against the statistics.

When more is understood about this difficult problem, more intelligent questions can be asked about income distribution. Rather than seeking or using a general purpose aggregate, strictly appropriate to no particular use, the facts relevant to a given problem can be carefully assembled and used with due discretion.

A generalization of the foregoing argument involves attacking the increasing specialization of much modern economic research. Is it desirable that an investigator should take over the half-cooked material of those in direct touch with the primary sources? Should he not start afresh himself, and construct his estimates and make his approximations in full knowledge of the end-use of the figures derived? Such a recommendation is, indeed, a counsel of perfection. It would be nice if every statistical practitioner could be the master of the processes at every stage in the manufacture of derived statistics, but the fields of investigation are now so broad and both time and possibly all-round ability are scarce. All that can be reasonably asked of research workers is that they use their knowledge and discretion to determine in what situations the use either of off-the-peg aggregates or of statistics made to a problem's own measure is appropriate.

In reviewing such an extensive and detailed collection of papers, full justice can scarcely be done to all contributors. Comment must be confined to selected items that appear, at the moment, to be most provocative of thought. This book will provide ample stimulation to those statistical economists, who wonder what they can hope to learn from distributions of income or who, although more confident about such distributions' merits, are doubtful whether a sample survey will yield either what they expect or hope for.

To help prospective readers to see what else the volume contains, the following is a list of the titles and authors of the ten papers:

Research on the Size Distribution of Income, by Dorothy S. Brady.
Post-war Changes in the Income of Identical Consumer Units, by George Katona and Janet A. Fisher.
Distribution of Non-money Income, by Margaret G. Reid.
Distribution of Income Before and After Federal Income Taxes, 1941–1947, by Joseph A. Pechman.
Size Distribution of Farm Operators' Income in 1946, by Nathan M. Koffsky and Jeanne E. Lear.
Appraisal of Basic Data Available for Constructing Income Size Distributions, by Selma F. Goldsmith.
An Income Size Distribution from Income Tax and Survey Data, by Maurice Liebenburg and Hyman Kaitz.
Co-ordination of Old-Age and Survivors' Insurance Wage Data with those from Other Sources, by Benjamin J. Mandel.
Field Surveys of Consumer Income: An Appraisal by Robert Wasson, Abner Hurwitz and Irving Schweiger.
Estimating the Number of Earners for Income Size Distribution Analysis, by Emmett H. Welch.

A. D. ROY.

9.—*The Nature and Tax Treatment of Capital Gains and Losses.* By Lawrence M. Seltzer. New York: National Bureau of Economic and Social Research., 1951. xii + 554 pp. 9″. $7.50.

The aim of this book is to present an objective, critical analysis of the opposing views on the treatment of capital gains and losses for taxation purposes. It is rather to provide the information upon which opinions can be based than to put forward recommendations. The subject has been approached in a straightforward manner and the many aspects of it fully covered, in addition to the many other related issues.

Although the problem is primarily treated from the American viewpoint, this is because it is American data upon which the more detailed studies are based. In considering the actual treatment of capital gains, a full comparison of the conditions in Britain, the Commonwealth and in other European countries is given, as is right in a matter which is of universal current importance.

After giving a general background, the difference between income and capital gains is fully discussed from the legal viewpoint, and then more fully in the economic concept. The difficulties that arise in the separation of capital gains from income are frequently encountered, and various treatment has been given by the United States Revenue Acts. While the nature of capital gains must be that they are unexpected is one theory, and others maintain that they must be related to

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assets held for capital purposes, their inclusion within National Income has been the subject of much discussion elsewhere. Are capital gains due to variations in the value of money to receive separate treatment because there is no increase in the spending capacity of the holder of assets so effected? Are capital gains due to a variation in interest rate trends to be treated likewise? Frequently such changes are expected, and thus a gain obtained in the light of such an expectancy is not within some concepts of a capital gain. Indeed excess of operating profits may exceed expectations, but cannot, therefore, be classed as capital gains, and more apparent is the case of operating losses, which would frequently be avoided if they were expected. The importance to be attached to realization and many of the discrepancies between the various concepts is also discussed, and thereafter the factors that relate to the justification of special treatment of capital gains for tax purposes, the unfairness of taxing many types of capital gains that arise, the extent to which the gains are balanced by the losses, the ability of the recipients to bear a corresponding share of country's expense.

On the basis of American data, Professor Seltzer has set out much valuable information on the effects that have resulted from different degrees of taxation of capital gains and losses over the years since 1917 upon the behaviour of investors, the distribution of the gains, and the resultant Federal Revenue. From the Tax standpoint the line between capital and income is further narrowed by the numerous methods adopted to avoid taxation in a legal manner, income being received in the form of capital gains. Avoidance of taxation in this manner has likewise been the subject of legislation in this country, in an effort to prevent the maintenance of profits within a business until it is distributed as capital. In this aspect, moreover, it is accepted that if the gains or losses are only to be taken into account when they are realized, considerable differences in the tax payable may result from postponing the date of realization to another financial year; when capital losses can only be set off against capital gains, the opportunity for avoiding immediate taxation arises when it is possible to obtain a capital loss by the sale of a capital item at the close of the year, and in order to obtain greater relief, capital losses have been converted into ordinary losses, where the rates have made it worth while.

Before considering the various proposals for tax treatment of capital gains and losses the actual treatment that the subject is given at present in various countries is considered. The one extreme is treatment of all gains and losses alike, whether capital or income, a practice which apparently exists in Greece to-day. Other countries exclude all gains and losses, but the capital item concerned must have been held more than a stated number of years, such as five for securities in Sweden, in order to be classed as capital. Another approach is by way of capital levies, and even in the countries which may claim to have no capital gains tax it often exists under other guises. Capital gain from the ownership of land can now be fully eliminated by development charges in this country; capital transfer duty has also the result of absorbing part of any possible capital gain, and makes no allowance for loss.

By way of summarizing the information that is provided by this study, there are set out the cases for and against exclusion of or separate treatment for capital gains and losses from the taxation standpoint. Amongst these are the traditional concept of income to be regular and more or less expected, the view that taxation on appreciation in value is forestalling the increased future income expected and often the cause of the nominal gain, and that this involves a double taxation, the iniquity of taxation upon nominal gains due to movement of price levels or interest rates, and the unreasonably high taxation, if a graduated scale exists, that has to be borne in the year of realization. The argument is frequently put forward, moreover, that taxation of capital gains frequently prevents realization, and that the movement of capital is consequently restricted. Lastly, capital gains and losses tend to balance, and the revenue as well as fluctuating violently is not finally material.

Against these can be found opposing views. Tax should be based upon the capacity of the taxpayers, irrespective of the source of their wealth; the impossibility of clearly separating the capital gains from income makes preferential treatment of them inequitable. It is contended that the difficulties are too many to warrant special consideration of gains due to variation in price levels, except in extreme times, when it has already proved necessary in continental countries. Indeed, for each case there is a counter opinion, and all have some justification.

However, proposals for meeting the situation include a tax based upon the increase in net wealth, a system whereby both income and tax liabilities are averaged over a number of years, and methods of averaging capital gains and losses alone, or of spreading them over the time the asset has been held. Doubtless, many proposals along similar lines or from a new approach to the problem will arise, for as Professor Seltzer states, "the whole concept of taxable income is relatively new and still evolving". He has given us in this book, however, an excellent basis for further consideration of any such views, and of the position that has arisen so far.

I. G. BUTLER.

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10.—*Coffee, Tea and Cocoa.* By V. D. Wickizer. Stanford University Press (London: Geoffrey Cumberlege), 1951. xiii + 497 pp. 9″ × 6″. $5.00. (Price in U.K., 40*s*.)

The Food Research Institute of Stanford University has undertaken, with the financial support of the Rockefeller Foundation, to "insure the competent preparation of a series of some twenty volumes designed to illuminate the complex aspects of food agriculture and World War II". Of these the present study is the first to be published. As such, and because of the importance of the United Kingdom as an importer, and of the Indian sub-continent and West Africa as producers of two of the three commodities with which its author deals, the study should draw in this country the attention it merits on grounds of competence and lucidity.

Taking each commodity in turn, V. D. Wickizer first briefly discusses its development from the time it appeared on the world market and the traditional problems of its cultivation, processing and distribution. In this setting he describes the specific marketing schemes which have evolved and the impact on these of the second world war. He concludes the section devoted to each commodity with an analysis of post-war developments and problems. Although the three commodities are thus separated for clarity of treatment, the author in fact makes frequent and useful cross-references. In particular he is skilful in showing the influence of specific botanical factors on the size and management of production units and on the forms taken by the various marketing schemes; he contrasts, for example, coffee, which is subject to wide variations in yield beyond the control of the producers in the short term, with tea, where considerable control over yield is permitted by adjustment of plucking operations. Tea, again, requires to be processed locally, requiring machinery and skilled supervision beyond the capacity of the small native producer, and this makes the plantation system almost inevitable, whereas cocoa of ordinary commercial grade is processed in the country of consumption and is mainly produced in West Africa on small native holdings of 2–5 acres.

At the outbreak of the Second World War the world coffee situation was still critical. Following the setting up of the National Coffee Department in Brazil in 1933, a "sacrifice" quota plan had been introduced under which, in 1937, 17·2 million bags out of a total crop of 26·4 million bags had been burned in an effort to stabilise the price. Owing to her failure at the Havana conference of 1937 to secure similar action by other South American producers, Brazil was forced to abandon these methods in favour of free competition. Prices sagged, and by 1940 had recovered but little above 1938 levels. After describing in some detail the effects of shipping and import restriction, and of coffee rationing in the U.S.A., Wickizer concludes that the controls of World War II created no lasting hardship, being largely offset by an increased world demand consequent on higher consumer incomes and shortages of other foods which persist to the present day.

Probably the most interesting part of the section on tea will be, for British readers, the chapter on British management of the war-time tea trade. Almost as soon as war was declared in 1939 control of both wholesale and retail prices was established, the London tea market was closed, and the Ministry of Food shortly took over the purchasing of tea from growers at fixed prices. With the later entry of Japan into the war, and the consequent elimination of the Dutch producers, the tea industry became almost exclusively British. But apart from commenting on the effect of bulk buying at fixed prices on the differential profits of producers, on the inevitable emphasis on quantity rather than quality which bulk buying entailed, and (to producers and other importing countries at least) the enigmatic nature of the Ministry of Food's policy, which continued well after the end of the war, Wickizer confines himself in the main to a description rather than analysis of developments.

Of considerable interest, too, is the dispassionate description of the "great cocoa controversy"—the struggle of trade interests in the U.S.A. to prevent the establishment of West African marketing schemes largely evolved during the Second World War. In spite of the British claim (Cmd. 6950) that the schemes did not aim at the exercise "of a dominating influence in the world cocoa market", few, in America at least, believed that anything other than a world cocoa "squeeze" was planned.

Perhaps the weakest part of the study is the section on demand, consumption and competition, which makes no real attempt to estimate consumer preferences or the relations of substitution between the three commodities considered as beverages. This section should, however, stimulate econometricians, who might usefully take Wickizer's discussion of the problems of analysis as a starting-point for further work.

The whole study is well referenced and the index is good; in addition to data given in the main text, twelve appendix tables cover production, export, import and price data for the period 1930 to 1950; in most cases 5-yearly averages are given for the pre-war years, and annual figures from 1940.

J. A. C. Brown.

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STATISTICAL NOTES

(1) British Official Statistics

As from February, 1952, the method of calculating the index of retail prices by the Ministry of Labour and National Service has been revised. The change is mainly in the weighting system, but there have also been a few alterations in the list of items included and the method of measuring changes in the level of rents has been revised. Hitherto the weights have been roughly proportional to the June, 1947, cost of the quantities of the various items used in 1937–38. The new weights are proportional to the estimated consumption in 1950 valued at the prices ruling in January, 1952. This method has been adopted as a temporary expedient until the results of a new budget inquiry become available. For the revised index the level of prices at January 15th, 1952, is taken as 100. Figures continue to be published for each of the main groups of items, but these cannot be linked to those for the separate groups for earlier dates. The overall figure for all items can, however, be linked, and the Ministry continues the publication of the series on the basis of June, 1947 = 100. This series shows that the index, which had reached 132 in January, rose to 133 in February and March. The group figures for these months, based on January 15th, 1952 = 100, are as follows:

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*House-hold Durable Goods*	*Miscel-laneous Goods*	*Services*	*Alcoholic Drink*	*Tobacco*	*All Items*
Weights:	399	72	98	66	62	44	91	78	90	1,000
Feb. 12th	100·1	100·1	99·7	100·3	99·9	100·3	100·3	100·1	100·0	100·1
Mar. 11th	100·8	100·2	100·0	100·5	99·7	101·3	102·3	100·1	100·0	100·6

The Ministry of Labour index of weekly wage rates, which was 127 (June, 1947 = 100) in January, rose to 128 in February and March. At the latter date the figures were 127 for men, 131 for women and 134 for juveniles.

The six-monthly inquiry into average earnings, the results of which became available in March, showed that in October, 1951, the average weekly earnings in the industries covered by the Ministry of Labour returns were 166*s.* for men, 90*s.* 1*d.* for women, 69*s.* 1*d.* for youths and boys and 57*s.* 11*d.* for girls. These figures represented increases over October, 1938, of 141, 177, 165 and 213 per cent. For all workers combined the average was 141*s.* 1*d.*, 165 per cent. more than in 1938. It is estimated that in the industries covered by the inquiry rates of wages have risen by 5 to 6 per cent. since October, 1951. The index number for October, 1951, compared with 100 at April, 1947, was 136. The average weekly hours worked fell slightly from 46·3 in April, 1951, to 46·1 in October. In manufacturing industries alone the average weekly earnings of men in October, 1951, were 172*s.* 1*d.*, and those of women, 90*s.* 7*d.*

The total working population and the numbers in civil employment between December and February were as follows:

	Total Working Population			*Number in Civil Employment* (*Thousands*)		
	Males	*Females*	*Total*	*Males*	*Females*	*Total*
Dec., 1951 . .	16,007	7,419	23,426	14,975	7,246	22,221
Jan., 1952 . .	16,035	7,419	23,454	14,972	7,231	22,203
Feb., 1952 . .	16,031	7,401	23,432	14,958	7,200	22,158

The level of unemployment rose from 378,741 in January to 393,480 in February and 432,974 in March, the increases being mainly in textiles. The figures are analysed below:

Number of Unemployed Persons on the Registers of Ministry of Labour Employment Exchanges

Date	*Men and Boys*	*Women and Girls*	*Total*
Jan. 11th, 1952 . . .	216,379	162,362	378,741
Feb. 11th, 1952 . . .	224,894	168,586	393,480
Mar. 17th, 1952 . . .	229,974	203,000	432,974

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It is estimated that the number of unemployed persons on the registers at March 17th represented 2·1 per cent. of the total number of employees. The percentage in the Regions ranged from 0·8 in the Midlands to 3·7 in the North-West, 3·3 in Scotland and 3·0 in Wales.

The number of insured persons absent from work owing to sickness, including self-employed as well as employed, was 936,700 in January, 1952, 974,200 in February and 937,200 in March. All these figures were lower than a year earlier. The number of employed persons absent owing to industrial injury was 58,900 in January, 61,500 in February and 59,900 in March.

Figures recently published in the *Ministry of Labour Gazette* show that in the manufacturing industries and the non-manufacturing industries, excluding coal-mining, agriculture, railway service and the retail distributive trades, the proportion of employees paid by results was 32 per cent. in October, 1951. This compares with 28 per cent. in October, 1947, and 25 per cent. in October, 1938. The corresponding percentages for men only were 28, 24 and 18. The figures for women were 44, 39 and 46. In manufacturing industries alone the percentage of all workers paid by results in October, 1951, was 40, the figure for men being 38 and that for women 48.

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(2) Other Statistics

The third issue of the *United Nations' Statistical Yearbook*, dated 1951, follows mainly the lines of its predecessors. A few tables in the chapter Population have been omitted, and a new chapter on Consumption however is added, which gives statistics of the gross supplies of foodstuffs (in thousand metric tons) and net supplies for human consumption *per capita* (in kilograms); it also contains the results of a first study on the estimated consumption of the chief sources of energy (mineral fuels and water power but not wood and vegetal fuels) expressed in terms of coal.

An important change in presentation is that all index numbers have been recalculated, wherever possible, on the basis 1948 = 100, instead of 1937 = 100 as in previous issues. Another improvement is that the former appendix of statistical series covered by international statistical yearbooks has now been enlarged to include periodical publications other than annual; about 50 publications of an international character are now listed.

For the majority of the tables the period covered is the 20 years 1931–50, though data for the early months of 1951 are given in a few tables. The Country Index lists nearly 250 countries and other territories for which statistics are given in one or other of the tables.

The third issue of the *United Nations' Demographic Yearbook*, dated 1951, is devoted mainly to the subject of mortality—more than one-half of the volume being devoted to this subject. Deaths and death-rates by sex, by age and by causes of death; infant deaths, and mortality rates by age and sex are given for many recent years. This volume is more than a mere yearbook of statistics, as it gives a chapter on recent mortality trends and one on the development of statistics of causes of death; another special feature is the appraisal of the quality of the data for population estimates and for vital statistics by an ingenious system of code letters. A cumulative index of the first three issues is now added, as the subject of emphasis changes with successive issues. The extensive bibliography prepared by the U.S. Library of Congress and Bureau of the Census for the second issue is not repeated, but a supplement of 24 pp. gives new titles which did not appear in the previous issues.

The International Statistical Institute in its conduct of a programme of international statistical education, under the sponsorship and with the financial support of UNESCO, has been preparing such aids to teaching as dictionaries and bibliographies. In 1951 a bibliography on basic material in the English language was published, in typescript, which should prove a useful reference book. (*Bibliography of Basic Texts and Monographs on Statistical Methods*. The Hague, I.S.I., price 5*s*.)

The compiler is Dr. W. R. Buckland, working under the direction of Professor Maurice G. Kendall. The items, about 100 in number, are drawn mainly from publications of the last decade but include earlier works of outstanding importance. They have been selected as affording means for students, teachers and practising statisticians to review their acquaintance with recent non-periodical work on the theory and main applications of statistical method.

The bibliography is more than a mere list of routine publication particulars. Chapter-headings

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for each item give a general idea of the subject matter. The character of the item is then demonstrated by short extracts from reviews in the four main statistical reviews published in English, viz.:

Journal of the Royal Statistical Society.
Journal of the American Statistical Association.
Biometrika.
Sankhya.

These are chosen to indicate the type of reader addressed, the method of treatment, the extent to which the author succeeds in his object, some criticism of both matter and manner, and, in the case of text-books, the degree of usefulness of examples and exercises where these are provided. The choice appears to serve its purpose well; the user of the bibliography should gain quickly and economically a good idea of the books, etc., likely to meet his individual needs.

CURRENT NOTES

The appearance of a new statistical journal is a major event to all statisticians. *Applied Statistics*, the first number of which was published in March, 1952, seeks to meet the needs of the rapidly growing body of workers in science, industry and commerce who, though not necessarily statisticians, may find themselves confronted with the results of statistical investigations embodying techniques unfamiliar to them or studying problems for which statistical methods would be useful if their nature and application were appreciated. So wide is the field of statistical application, and so varied the users or would-be users of the newer techniques, that neither of the two series of journals hitherto published by the Society could fulfil its original purpose and at the same time satisfy legitimate demands for the dissemination of practical knowledge in a form suited to readers whose primary interest lies outside theoretical statistics. The aim of the new publication, as set out in the foreword contributed by the President of the Society, Professor A. Bradford Hill, is to present in one way or another, but always clearly, the statistical approach and its value, and to illustrate in original articles modern statistical methods in their everyday applications.

The first issue can give only a sample of the features of the new journal. Commerce and industry are always likely to be strongly represented; the editorial committee hope also to include in future issues articles to interest economists and social scientists, medical scientists, agricultural scientists, chemists and physicists, engineers and technologists. Reports of the proceedings of the Industrial Applications Section and of the Study Section will appear periodically and will, it is hoped, attract workers to whom these sections have not hitherto been known to take an active share in their meetings. Readers are invited to contribute to "Questions and Answers" and to "Letters to the Editor."

Fellows must wish the first editor, Mr. L. H. C. Tippett, and his committee success, and can contribute to the establishment and long life of *Applied Statistics* by supporting the new journal themselves and by bringing it to the notice of those other workers for whose interest and assistance it is planned.

The National Institute of Economic and Social Research has appointed Mr. W. A. B. Hopkin as Director of the Institute. Mr. Hopkin was Wrenbury Scholar at Cambridge in 1936 and entered the Administrative Grade of the Civil Service in 1938. He was Assistant Secretary to the Royal Commission on Population, has been an Economic Adviser in the Economic Section of the Cabinet Office and has been working as a Chief Statistician in the Central Statistical Office. He takes up his duties at the Institute on October 1st, 1952.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

Accounting Research—

January 1952—The "economic facts of life" as shown in the correlation of accounting, economics and law: *J. L. Dohr*. Design for the accounts of Society: *F. Sewell Bray*. Le "Plan Comptable International": *M. Mommen*. Measurement of national income and construction of social accounts for an industrially backward economy—II: *V. M. Dandekar*.

Agricultural Economics Society, Journal of Proceedings—

January 1952—The changing British economy: *Sir H. Clay*. One agricultural economist to another: *C. V. Dawe*. The future of agricultural marketing: *T. J. Shaw*. The political economy of British forestry: *J. J. Macgregor*. Impressions of American agriculture: *R. N. Dixey*. Notes on the work-unit method of measuring productivity of labour: *C. H. Blagburn*.

British Journal of Psychology—

November 1951—A factorial study of mathematical abilities: *M. K. Barakat*. Information theory and intelligence tests: *W. E. Hick*. A factorization of tests of personality source traits: *R. B. Cattell*. Factor analysis of assessments for a single person: *C. Burt* and *H. Watson*.

March 1952—The fundamental equation of factor analysis: *H. Kestelman*. Factor rotation by the method of extended vectors: *T. Kershaw*. A factorial analysis of items in the Bernreuter Personality Inventory: *C. Banks* and *G. Keir*. The application of analysis of variance to problems of correlation: *A. E. G. Pilliner*. The nature and causes of maladjustment among children of school age: *C. Burt* and *M. Howard*.

British Journal of Social Medicine—

January 1952—Tuberculosis and the "social complex" in Glasgow: *L. Stein*. Psychiatric aspects of somatic immunity: *J. W. Lovett Doust*. Spread of influenza in a factory: *F. Acheson* and *D. Hewitt*.

British Journal of Sociology—

March 1952—Is it possible to prove any general statements about historical fact?: *L. F. Richardson*.

British Management Review—

December 1951—Productivity measurement and wage levels: *A. R. Smith*.

Geographical Journal—

March 1952—English conurbations in the 1951 Census: *E. W. Gilbert*.

Faculty of Actuaries, Transactions—

Vol. XX, Part II, No. 175—The individual and the State: *Sir A. Gray*. Widows' Funds: some notes on theory and practice: *D. A. B. Scrimgeour*. An actuary in commerce: *N. C. Turner*. Nomograms: *W. J. Cooksey*.

Journal of Documentation—

March 1952—Reading habits in three London Boroughs: *A. Stuart*.

Lloyds Bank Review—

April 1952—Halfway to 1960: *C. Clark*. The campaign against monopoly and restrictive practices: Sir H. Clay. Tea industry problems: *Sir P. Griffiths*.

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Manchester School of Economic and Social Studies—

January 1952—British social income estimates, 1938–1950: *J. Mars.* Voting behaviour in Droylsden in October 1951: *P. Campbell, D. Donnison* and *A. Potter.* Remedies for cyclical unemployment in the north-east: *J. Sykes.*

Mathematical Tables and other Aids to Computation—

October 1951—A guide to tables on punched cards: *G. Blanch* and *E. C. Yowell.* Formulas for finding the argument for which a function has a given derivative: *H. E. Salzer.*

Oxford Economic Papers—

February 1952—The demand for coal in Great Britain: *K. S. Lomax.* Statistical cost functions in electricity supply: *J. Johnston.*

Oxford University Institute of Statistics, Bulletin—

January 1952—National income: third quarter of 1951: *P. D. Henderson, D. G. Holland* and *D. Seers.* A "rent, dividends and interest" account for 1948: *J. R. Sargent.*

February 1952—Working-class food consumption from 1942 to 1949: *T. Schulz.* The national income in 1951 and future prospects: *P. D. Henderson, D. G. Holland* and *D. Seers.*

Population Studies—

March 1952—The assimilation of refugee immigrants in Australia: *H. B. M. Murphy.* The resettlement of displaced persons in the United Kingdom: *E. Stadulis.* A life table for a West Indian slave population: *G. W. Roberts.* Fertility and social mobility: *J. Berent.* Birth control and abortion in France since 1939: *C. Watson.*

Review of Economic Studies—

Vol. XIX (2) No. 49—Simple transaction models, information and computing: *R. Stone.* An engineer's view of the problem of economic stability and economic regulation: *A. Tustin.* The factor price equalisation myth: *S. F. James* and *I. F. Pearce.* A comment on factor price equalisation: *P. A. Samuelson.* The existence-conditions of a total utility function: *J. Ville.*

Royal Meteorological Society, Quarterly Journal—

April 1952—A statistical model for water-vapour absorption: *R. M. Goody.* A technique for wind analysis and forecasting as applied to Victoria, B.C.: *D. B. McIntyre.*

INDIA—

Calcutta Statistical Association Bulletin—

December 1951—Problem of making a decision: *H. K. Nandi.* Review of the National Income Committee Report: A reply: *The National Income Unit, Government of India*; a rejoinder: *A. N. A.* On multi-dimensional stochastic fields: *B. Ghosh.* An estimate of the location parameter of symmetrical populations: *D. H. Bhate.* Some three-replicate partially balanced designs: *K. R. Nair.* Weighing designs and partially balanced incomplete blocks: *K. S. Banerjee.*

UNION OF SOUTH AFRICA—

South African Journal of Economics—

December 1951—Native incomes, housing and the cost of living: *H. M. Burrows.* Differential mortality in South Africa: *J. L. Sadie.*

UNITED STATES—

American Academy of Political and Social Science, Annals—

January 1952—Social contribution by the aging (whole number).

American Economic Review—

March 1952—Underemployment equilibrium rates of growth: *R. Eisner.* A theory of the system of multilateral trade: *K. E. Hansson.* Cyclical changes in the balance of trade: *S. G. Triantis.* Domestic air line self-sufficiency: *H. D. Koontz.* Cost of production, price control and subsidies: *H. G. Brown.*

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American Statistical Association, Journal—

March 1952—Man as a planning animal: *L. J. Reed.* Some applications of statistics for auditing: *J. Neter.* Fertility trends and differentials in the U.S.: *C. V. Kiser.* Estimation for sub-sampling designs employing the county as a primary sampling unit: *E. H. Jebe.* Latent structure analysis and its relation to factor analysis: *B. F. Green, Jr.* Measuring magnitudes and trends in the production of livestock and meat: *A. V. Nordquist.*

American Statistician—

February 1952—Standards of statistical conduct in business: articles by *A. T. Court, M. H. Hansen* and *T. H. Brown.*

Bell System Technical Journal—

January 1952—Dialing habits of telephone customers: *C. Clos* and *R. I. Wilkinson.*
March 1952—The reliability of telephone traffic load measurements by switch counts: *W. S. Hayward, Jr.*

Biometrics—

December 1951—Why randomize: *B. G. Greenberg.* Statistical aspects of the simultaneous detection of thyroids and thyrotrophic hormones in human sera, based on the data of D'Angilo and Gordon: *C. H. Steinmetz.* Why I prefer logits to probits: *J. Berkson.* Accident statistics and the concept of accident-proneness: *A. G. Arbous* and *J. E. Kerrich.*

Econometrica—

January 1952—Overcapacity and the acceleration principle: *H. B. Chenery.* On the structure of linear models: *R. Solow.* Postwar changes in income and savings among consumers in different age groups: *J. A. Fisher.* Production relations in the railway industry: *G. A. Borts.*

Industrial Quality Control—

January 1952—Statistical methods in chemical development: *C. A. Bicking.* Control of complicated product: *D. A. Hill.* The empirical approach to the theories of quality control: *T. H. Brown.*

Milbank Memorial Fund Quarterly—

January 1952—Marriage and divorce trends in Wisconsin 1915–1945: *G. W. Hill* and *J. D. Tarver.* Seasonal differences in character of the "common cold" observed in two communities in Westchester County, New York: *J. Downes.* Incidence of acute respiratory illness among males and females at specific ages. Study No. 5: *D. Tucher, J. E. Coulter* and *J. Downes.* Social and psychological factors affecting fertility rates by adherence to traditions: *R. Freedman* and *P. K. Whelpton.*

Psychometrika—

December 1951—The factors in factoring behavior: *Q. McNemar.* A factorial study of the reasoning and closure factors: *W. A. Botzum.* Mathematical structures and psychological measurements: *A. M. Weitzenhoffer.* Estimation of the reliability of ratings: *R. L. Ebel.* A square root method of selecting a minimum set of variables in multiple regression—II. A worked example: *A. Lubin* and *A. Summerfield.*

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February 1952—Compulsory health insurance: the economic issue: *R. R. Campbell.* The theory of business cycles: *R. Fels.* Taxation and incentive in mobilization: *G. Cooper.* The quantitative study of factors determining business decisions: *G. Katona* and *J. N. Morgan.* The new welfare economics and gains in international trade: *R. E. Baldwin.*

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Soviet statistics: *L. Turgeon.* A note on Professor Frisch's trade matrix and discriminatory restriction of imports: *A. Y. C. Koo.* An application of the Durand Method for estimating the size distribution of a given aggregate income: *R. G. Townsend.* Statistical concepts in the Soviet Union examined from generally accepted scientific viewpoints: *S. A. Rice.*

FRANCE—

Journal de la Société de Statistique de Paris—

July–September 1951—Recensement général des agents des services publics en 1950: *M. Brichler.* Résultats de l'étude statistique du risque R.C. automobile: *P. Depoid.* Au sujet de la mortalité probabiliste: *J. Genevay.* L'évolution des probabilités des lois binômiales: *M. Dumas.*

October–December 1951—La mesure de l'endogamie et ses applications démographiques: *J. Sutter* and *L. Tabah.* Chronique des statistiques bancaires et des questions monétaires: *P. Cauboue.* Régression unilatérale et régression mutuelle: *R. Congard.* Le problème du choix des communes: échantillons à éléments tous distincts: *L. Henry.*

Population—

January–March 1952—Vieillessement de la population, besoins et niveau de vie des personnes âgées: *J. Daric.* Un dénombrement inédit au XVIIIe siècle: l'enquête du Contrôleur général Orry—1745: *Fr. de Dainville.* La mortalité, phénomène biométrique: *J. Sutter* and *L. Tabah.*

GERMANY—

Mitteilungsblatt für Mathematische Statistik—

Vol. 3, Part 3—Über die Anwendung statistischer methoden in der Fernsprechtechnik (Schluss): *K. Rohde.* Die Anwendung der "Streuungsanalyse (Analysis of Variance) auf quantitative wirtschaftliche Probleme unter Berücksichtigung der "Autocorrelation": *H. Stöwe.* Die Sheppardsche Korrecktur der Streuung: *P. Lorenz.* Korrelationstheorie mehrdimensionaler Merkmale: *W. Krull.* Reserveermittlung durch Stichproben in der Lebensversicherung: *G. Wünsche.* Möglichkeiten und Grenzen einer Quantifizierung des "Konjunkturtestes" des Münchener Institutes für Wirtschaftsforschung: *O. Anderson, Jun.*

HOLLAND—

Statistica—

Vol. 5, No. 3–4—Het gebruik van toevalscijfers: *J. H. Enters.* Verdelingsvrije methoden in de regressieanalyse van twee variabelen: *H. Theil.* Over de herleiding van B tot: *J. van Ijzeren.* Meting van immuniteit tegen toxoplasmose met behulp van vrije curven: *C. A. G. Nass.* Grafische bepaling van de tweevoudige correlatie-coëfficiënt: *V. Varangot.*

ITALY—

Giornale degli Economisti e Annali di Economia—

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SWEDEN—

Skandinavisk Aktuarietidskrift—

Vol. 3–4 (1951)—A probability distribution connected with Stirling's Second Class Numbers: *G. Arfwedson.* The problem of optimum stratification—II: *T. Dalenius* and *M. Gurney.* Demand functions and the integrability condition: *H. Wold.* Post-war mortality among industrial insured lives in Norway: *G. Harbitz.* Analytical studies in stop-loss reinsurance: *S. Vajda.* The sickness experience of the Valkyrian Insurance Company, 1929–1948: *K. Medin.* On the test of the hypothesis that the probability of an event is contained within given limits: *P. Ottestad.*

Statistisk Tidskrift—

January 1952—Den statistiska metoden: *H. Cramer.* Befolkningsregistret: *I. Uhnbom.* Omläggning av den arliga inkomststatistiken: *J. Sjöstrand.* Operationsanalys: *T. Dalenius.*

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SWITZERLAND—

Schweizerische Zeitschrift für Volkswirtschaft und Statistik—

December 1951—Die Schätzungen des sowjetrussischen Volkseinkommens. (Schluss): *J. Wyler.*

INTERNATIONAL—

Revue de l'Institut International de Statistique—

Vol. 19, No. 2—The variate-difference method in theory and practice: *M. H. Quenouille* Spécialisation, intégration et statistique internationale: *G. Goudswaard.* Estimates and their sampling variance of parameters of certain heteroscedastic distributions: *H. Theil.*

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LIST OF ADDITIONS TO THE LIBRARY

Since the issue of Part I, 1952, the Society has received the publications enumerated below.

I.—OFFICIAL PUBLICATIONS

(a) United Kingdom

Board of Trade. Dollar exports: sales to public authorities in the U.S.A.; a survey of purchasing legislation and practice in relation to federal, state, and municipal agencies. London, H.M.S.O., 1952. 186 pp. 13″. 12*s.* 6*d.*

Overseas economic surveys: Bolivia, May, 1951. iv, 36 pp. map. 1*s.* 6*d.* Ceylon, May, 1951. vii, 106 pp. map. 3*s.* 6*d.* Italy, February, 1951. xii, 156 pp. map. 5*s.* Malaya, March, 1951, ix, 189 pp. map. 6*s.* 6*d.* Switzerland, April, 1951, vii, 125 pp. map. 4*s.* 6*d.* United States of America, April, 1951, vii, 266 pp. maps. 8*s.* 6*d.* London, H.M.S.O., 1951–2. 9½″.

Department of Agriculture for Scotland. Scottish agricultural economics: some studies of current economic conditions in Scottish farming. Volume II. Edinburgh, H.M.S.O., 1952. 56 pp. 9½″. 1*s.* 9*d.*

Types of farming in Scotland. Edinburgh, H.M.S.O., 1952. 101 pp. 9½″. maps. 3*s.* 6*d.*

Department of Scientific and Industrial Research. Advisory Council. Report of the Committee on Chemical Engineering Research. London, H.M.S.O., 1951. iii, 36 pp. 9½″. 1*s.* 6*d.*

General Register Office. Abstract of legal preliminaries to marriage in the United Kingdom and other countries of the British Commonwealth of Nations and in the Irish Republic. London, H.M.S.O., 1951. vi, 189 pp. 9½″. 6*s.*

Interdepartmental Committee on Social and Economic Research. Guides to official sources No. 2. Census reports of Great Britain, 1801–1931. London, H.M.S.O., 1951. iv, 119 pp. 9½″. 3*s.* 6*d.*

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Observations on the general effects of injury in man, with special reference to wound shock . . . London, H.M.S.O., 1951. xiii, 313 pp. 9½″. 8*s.* 6*d.* (Special report series, 277.)

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Ministry of Labour and National Service. Cost of Living Advisory Committee. Report on the working of the interim index of retail prices . . . London, H.M.S.O., 1952. iv, 48 pp. 9½″. 1*s.* 6*d.* (Cmd. 8481.)

Ministry of National Insurance. Second report of the Ministry of National Insurance for the period 5th July 1949, to 31st December 1950. London, H.M.S.O., 1951. viii, 72 pp. 9½″. 2*s.* 6*d.* (Cmd. 8412.)

Treasury. A guide to government libraries. London, H.M.S.O., 1952. iv, 120 pp. 8″. 7*s.* 6*d.*

Preliminary national income and expenditure estimates 1948 to 1951. London, H.M.S.O., 1952. 16 pp. 9½″. 6*d.* (Cmd. 8486.)

University Grants Committee. University development: interim report on the years 1947 to 1951. London, H.M.S.O., 1952. 28 pp. 9½″. 1*s.* (Cmd. 8473.)

(b) Other National and International Publications

Brazil

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Economic Commission for Europe

The European tractor industry in the setting of the world market. Geneva, 1952. vi, 152, 20, 4, 3 pp. 11″.

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Methods and techniques of financing housing in Europe: study prepared by the Industry and Materials Division. Geneva, 1952. vii, 275 pp. table. 11″.

Transport Division. Annual bulletin of transport statistics, 1950. Geneva, 1951. 76 pp. 11″. 5*s*. (1951. II. E.2.)

Food and Agricultural Organisation

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Per caput fibre consumption levels. Rome, FAO, 1952. 24 pp. 11″. 25*c*. (Commodity series bulletin 21.)

International Labour Office

Year book of labour statistics 1949–50. 11th issue. Geneva, 1951. xviii, 431 pp. 12″. 30*s*.

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Population census of 1950. Volume I: total population. Tokyo, 1951. iv, 251 pp. maps, diagr. 10″.

United Nations

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Vol. CXV.] [Part III

Journal of the Royal Statistical Society

SERIES A (GENERAL)

PART III, 1952

Consumption of Raw Materials in the United Kingdom: 1851–1950

By C. T. Saunders

[Read before the Royal Statistical Society March 26th, 1952, the President, Professor A. Bradford Hill, C.B.E., in the Chair]

1. *Introduction*

1.1. This paper sets out one way of measuring the growth of manufacturing industry and the change in its structure. The method is to measure the consumption of the principal raw materials. Its main advantage over alternative measures is simply that "hard" and fairly comprehensive statistics are available for many years—although it will be shown that some of the raw material statistics are a good deal less "hard" than might be thought. The alternative measures of growth are direct statistics of physical output, and measurements in money values deflated by price indices. The drawback to the use of physical output statistics is that until the census of production of 1924 there are no statistics which can be treated as comprehensive, or even with any confidence as representative, for the sector of manufacturing industry whose growth is perhaps the most interesting of all—the metal-using industries (engineering in the broadest sense). Such general indexes of production as have been compiled over long periods in fact lean heavily for their coverage of this sector on what are really input series, e.g. the output of metals. Measurements of the output of manufacturing industry based on money values, which might be extracted from national income estimates, must be unreliable for the years before 1924 for the same reason: because of the lack of physical output data and the heterogeneity of output in the metal-using industries, the accurate measurement of price changes becomes an intractable problem.

1.2. It is not suggested that statistics of raw material consumption, however complete—and the statistics cannot in fact be complete—provide in themselves an adequate measure of the volume of output. They may, however, be of some interest in their own right as indicators of changes in the rate of economic expansion; they show the shift in emphasis from one broad group of industries to another, and they illustrate the shifts within an industry from one material to another. They provide one kind of scaffolding for economic history.

1.3. The statistics of raw material consumption lead on, moreover, to study of the changing relationships between raw material input and the volume of output—changes in the "productivity" of raw material. Dr. Barna in his paper to the Society in December, 1951, exhibited the general relationship between input and output in one year (1935). The present paper is in part a contribution to the complementary study of the way in which the relationship between input and output has changed over time. But while Dr. Barna was able to present the complete matrix of input/output relations in the economy as a whole, I have done no more here than put forward a few sketchy indications of the kind of changes that have occurred between one form of input—raw materials—and output in some branches of the economy.

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1.4. The paper presents estimates of the consumption of 16 major raw materials in the United Kingdom from 1851 to 1950. The materials are:

Metals	*Textile Materials*	*Other*
Finished steel	Cotton	Softwood
Iron products	Wool	Rubber
Copper	Rayon	
Zinc	Silk	
Lead	Flax	
Aluminium	Hemp	
Tin	Jute	

The way in which the estimates have been compiled is set out in *Part* 2.

1.5. *Part* 3 of the paper is concerned with the relation between raw material input and output during the period for which statistics representing both concepts can be studied—the years since 1924, and in a more limited way between 1907 and 1924, which are covered by censuses of production and by fairly complete indexes of production. This may provide some clue to the reliability of input series as a guide to output trends over longer periods. The comparison is probably of most interest for the metal-using industries; it is also relevant to the textile-using industries (i.e., the textile and clothing industries), although in this sector the relationship between input and output is perhaps less complex and there are more complete statistics of actual output.

1.6. Something is said in *Part* 4 of the course of the long-term trends illustrated by these series, and especially of the contrast between the different sectors of the economy.

1.7. The expansion of manufacturing in this country has been accompanied by an absolute, as well as by a relative, decline in our own output of some of the basic materials which we are able to produce ourselves—certain metals and fibres. *Part* 5 deals with this aspect of our increasing dependence on imports for the expansion of output.

2. *The Statistical Material*

General

2.1. The object is to compile as many continuous series as possible to represent the consumption trends of the more significant raw materials. But what is to be the criterion of a raw material? The problem of definition is most obvious and most acute in the metals. In iron and steel, for example, one might take consumption of raw material to mean consumption of iron ore, iron ore plus coke, pig-iron, pig-iron plus scrap, ingot steel, or finished steel.

2.2. Within the limits of available data the object has been to compile series representing consumption of raw material at as late a stage as possible in the productive process mainly because one purpose of the investigation is to find a series which can be compared with the output of finished goods. Thus it is important to exclude the exports, and include the imports of semi-manufactured goods (e.g., pig-iron and crude, semi-finished and finished steel and non-ferrous metals). The volume of external trade in such products—which may be described as "raw materials", or "semi-manufactures", or "manufactures" at will—has varied substantially over the century, but in few cases has been continuously so small that it can safely be ignored. It is obviously subject to completely different considerations from those determining the demand at home or abroad for the finished products of British industry.

2.3. The point at which "raw material" ends and the "manufacturing" process begins, for the purpose of this paper, is not indisputably comparable for every category of raw material. The statistics for the various metals are based on a roughly comparable line of demarcation—the consumption of finished metals. The series for textile materials relate to the consumption of raw fibres.

2.4. The second general statistical problem is to determine how to arrive at reasonable estimates of "consumption" of raw material. Until World War II there were almost no direct and continuous statistics of consumption of raw materials by industrial users. The only important comprehensive information available is the statistics in the Censuses of Production; but until the 1935 census the section of the census dealing with the quantities of specific raw materials used was not sufficiently developed to provide adequate information for this purpose.

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2.5. Before World War II consumption must in most cases be estimated from available supplies—U.K. production plus imports less exports and re-exports. Changes in stocks are not known (particulars of stocks held at port warehouses are available since World War I for certain materials—timber, some non-ferrous metals—but have not been used here). For this reason it is impossible to attach much importance to the year by year fluctuations. The series are therefore reliable only in the form of annual averages for periods of years, so that no gross error is likely to arise from the ignoring of stock changes, and supplies available can be taken to be for practical purposes identical with industrial consumption.

2.6. During World War II the various raw material controls instituted statistical reporting systems which provide continuous records of industrial consumption, although some of these refer to industrial consumers' receipts of material and not to their actual usage. Most of these records have been kept up since the war either by Government Departments or by trade associations. The annual figures in this paper during and since World War II are based on these consumption figures (although not always identical with them because of differences in definition), and therefore have more validity than the annual figures for previous periods.

2.7. The periods of years over which the statistics are averaged are intended to be trade cycles, each period beginning with the peak year of a cycle. In principle, evening out over a trade cycle should be more accurate than the obvious alternative of averaging five or ten-year periods; whether it makes much difference in practice is doubtful. The peaks have been selected from Colin Clark's series of real income (14) and Lord Beveridge's index of industrial activity (3). The periods of the two world wars are treated separately (averages being given for 1914–18 and 1940–44). Some of the more recent periods are broken into two (e.g., the cycle 1929–36 and the period 1945–50), but otherwise the averages refer to periods of between 5 and 8 years.

2.8. The figures for each year are given in the Appendix, together with details of their compilation. A brief account of some features of the estimates should, however, be given here to illuminate their interpretation.

Metals

2.9. The purpose is to get series for the consumption of metals which will represent as nearly as possible the raw material input of the industries producing finished metal goods. The industries concerned, which may be described as the "metal-using" industries, include all branches of mechanical and electrical engineering, shipbuilding, the manufacture of aircraft, and of rail and road vehicles. Broadly they are the industries included in Orders VI to IX in the Standard Industrial Classification. In this group of manufacturing industries metals are the predominant raw material. These industries are not, however, the only important users of metal. One problem in comparing metal input with industrial output is to determine how far comparison may be upset by the changing proportion of iron, steel and non-ferrous metals used directly in building (for which metals are by no means the predominant raw material). A proportion of finished metal goods is also produced outside Orders VI to IX, in particular the output of cast iron products by iron foundries; such output cannot easily be distinguished in statistical classification from the output by foundries of such items as castings for machine tools which reappear in finished form in the output of the mechanical engineering industry.

Iron and Steel

2.10. For this important component a series showing available supplies of finished steel (deliveries to U.K. users in ingot equivalent) from 1900 to 1946 has already been compiled (16). To avoid overweighting of other metals, this series has been converted into finished weight. The series can be linked to the statistics published by the British Iron and Steel Federation for 1920–50. An attempt has been made to take the figures back to 1851 from production and trade statistics. The problem now arises of the distinction between iron and steel, since series showing steel consumption alone would grossly exaggerate the rise in the input of the metal-using industries. The Bessemer process was introduced in 1856, and the first statistics of steel output are for 1857 (40,000 tons) when 3·7 million tons of pig-iron were produced: even by the end of the 19th century only about half the pig iron was used for steel-making. It is clearly necessary to estimate iron as well as steel consumption. At present, of course, these iron products are almost wholly castings

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and wrought iron, but in earlier years they included as well bars, sheets, plates, including ship plates, rails, etc., which are now almost exclusively steel. The physical distinction between iron and steel is primarily that steel is pig-iron with the carbon content reduced by oxidizing in the steel converter or furnace. But customs officers do not, for the sake of statistical accuracy, test for carbon content. Nor can the merchants who fill customs documents be trusted to do so. Hence for much of the 19th century, the trade statistics do not attempt the impossible task of dividing imports and exports of sheets, plates, rails, etc., between iron and steel, and such distinctions as are made in the trade account headings between iron and steel may well be misleading.

2.11. Probably the only series for which much validity could be claimed over so long a period would be a combined index of iron and steel consumption. But in the latter part of the period the steel consumption series has its own importance, and is better statistically than the combined series would be. Separate series have therefore been compiled over the whole period 1851–1950 for the consumption of finished steel and for that of finished iron products.

2.12. To produce the steel series before 1900, an arbitrary division had to be made of the various items of iron and steel imports and exports. Thus it was assumed (*a*) that until about 1870 all ambiguous items could be treated as wholly iron; (*b*) that the important export trade in rails consisted wholly of iron rails until the trade fell off in the early 1870's, and that the transition to steel rails was pretty well complete by the time the trade had recovered in the early 1880's (5); (*c*) that in other products (sheets, plates, wire, etc.) there was a much slower rise in the proportion of steel to iron, extending from 1870 to 1900. These assumptions, arbitrary as they are, produce results for the early 1900's very close to the series for steel consumption for 1900–1950 already referred to; for this series, also, similar problems must have been encountered in estimating steel imports and exports in the early 1900's.

2.13. The next problem is to get a series for the supply of iron products. The estimate is somewhat hazardous. The method adopted is:

(*a*) Estimate the total consumption of pig-iron (excluding blast-furnace ferro alloys) from production, imports and exports.

(*b*) Estimate how much pig-iron goes into steel-making. From 1920, annual estimates are published by the British Iron and Steel Federation. For 1850–1919 an estimate —or rather a guess—has been made by taking separately the production of Bessemer and open-hearth steel, and by assuming (i) that the Bessemer process requires 1 ton of pig-iron for 1 ton of steel; (ii) that in the open-hearth process, the proportion was, until 1914, 0·75 tons of pig-iron for 1 ton of steel, the remainder of the charge being mainly scrap;* in World War I the scrap proportion is assumed to have increased somewhat as a result of official stimulation.

(*c*) We now have the amount of pig-iron used for purposes other than steel-making. But in the manufacture of foundry and forge products a proportion of scrap is also used, and has been used over most of the period concerned. Iron castings for instance are about 50 per cent. scrap at present, but figures of scrap consumption by foundries have been published only since the war. A very rough guess can be made for 1935 by taking the excess of the output of iron products (so far as it can be determined from the Census of Production) over the amount of pig-iron available for purposes other than steel-making. This excess is 500,000 tons. The best we can then do is to assume a steady increase in the net amount of scrap used for iron products

* In fact, the pig-iron: steel ratio in the open-hearth process no doubt varied considerably from year to year (as it has done in recent years, for instance between 48:100 and 62:100 during the 1920's). The ratio of 75:100 used for the period 1875 (when open-hearth production began) till 1914 is based on a statement by D. L. Burn (*Economic History of Steelmaking*, p. 176) that British steel makers were about 1890 using about 70 per cent. pig although continental producers were making much more extensive use of scrap. Burn also says (p. 369) that in 1914 the British steel industry (as a whole) was still using only 10–15 per cent. scrap. The Balfour Report (Committee on Industry and Trade; Survey of Metal Industries 1928, p. 19) also estimates the 1913 proportion of pig-iron used in steel manufacture to steel output at about 80 per cent. in total, which would give about 75 per cent. for open-hearth production. Whatever the exact figure, it is clear that until the 1914–18 War, the use of steel scrap was not much developed in the U.K. (just as the use of non-ferrous scrap seems to have been undeveloped until the 1939–45 war—see paragraph 2.18 below). M. S. Birkett ("The iron and steel industry since the war", *J. Roy. Statist. Soc.*, 1930, p. 345) gives similar figures.

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from *nil* before 1900 to 500,000 in the 1930's. This estimate, added to the supply of pig-iron, gives a series for the output of iron products.

(*d*) Finally we allow for imports and exports of iron products, as given by the arbitrary process described in 2.12.

2.14. The result is a highly untrustworthy series representing home consumption of iron products (either by industry or, in the case of finished iron products, by the final consumer). It is certainly not a series worthy of respect in its own right. The only excuse for using it is that it is one way of correcting the misleading impression of the trend of metal consumption that would be given if iron products were omitted. Thus between 1897–1901 and 1948–50 steel consumption was multiplied over 4 times, but combined iron and steel consumption less than $2\frac{1}{2}$ times.

Non-ferrous Metals

2.15. This section is confined to a study of aluminium, copper, zinc, lead and tin. The statistics of consumption normally published—the excellent series compiled from returns by processors to the Non-Ferrous Metals Statistical Bureau (continuing Ministry of Supply war-time series) since 1942—refer to the consumption of primary metal. These are not, however, quite what we want, since they represent consumption at too early a stage. Exported semi-manufactures (plates, sheets, strip, sections, angles and shapes, tubes and all exports of brass) are treated as part of U.K. consumption, and similar imports are excluded from U.K. consumption and at certain times foreign trade in non-ferrous semis has been substantial. To provide series representing more nearly consumption by the producers of final products, I have therefore added the imports and deducted exports of non-ferrous metals in all identifiable forms (including brass which has been reallocated between copper and zinc on the basis of 2 : 1). The classifications in the trade accounts make it necessary to include a certain number of finished products which might more properly be excluded.

2.16. For production by U.K. smelters, complete statistics are available since 1920 (also for 1913) from the Imperial Mineral Resources Bureau (12), but unfortunately, only since the British copper and lead-smelting industries had declined to very low levels of activity. For earlier periods only rough estimates can be made from the continuous series of records of the production of ores and concentrates in the U.K. (13), and from the net imports of ores and concentrates. These estimates involve assumptions about the metal content of imported ores which are dubious, since it must vary considerably according to source and over the course of time.

2.17. Since 1942 statistics of stocks are available, and have been used to adjust the estimates of consumption for 1942–50 derived from production, imports and exports. The stock records do not, however, cover the stocks held by final processors.

2.18. One large and not accurately soluble problem remains in the statistics for all the non-ferrous metals—the use of secondary metal, or scrap. From 1942 the Non-Ferrous Metals Bureau statistics include scrap consumption, and some figures are given for 1935 in the Census of Production for the non-ferrous metals trade. An estimate can also be made of the amount of scrap consumption in 1935 by comparing the figures which I have derived by the methods described above with the Census of Production records of materials used (which include, of course, consumption of scrap metal in the final processing industries but do not there distinguish it from new metal, and which has the defect that direct use of non-ferrous metals in building is excluded and must be roughly estimated). This comparison shows that total consumption of new and scrap metal in 1935 can have been very little in excess of total consumption of new metal as estimated by my method. Allowing for the fact (which can be shown by a similar comparison from the Census for 1948) that the census tables of materials used include a certain amount of duplication between trades, it seems that the use of scrap copper in 1935 cannot have exceeded about 50,000 tons (in 1950 it was 188,000 tons), and that the use of scrap zinc and lead must have been even smaller (by 1950, 91,000 tons of scrap zinc and 165,000 tons of scrap lead was used). Not much weight can be put on these estimates for 1935, but at least they suggest that omission of scrap from the consumption estimates before World War II, and its inclusion during and since World War II, would not create an overwhelming distortion in the continuity of the series. In fact I have used these 1935 estimates to smooth out the consumption series a little, by assuming a gradual increase in scrap usage from *nil* in 1929–32 to small amounts in 1933–39, and a more rapid increase in 1940

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and 1942 up to the large amounts actually recorded for 1942 and thereafter. The assumption, embodied in the series, that no scrap was used before the mid-1930's is undoubtedly wrong, but there seems no way of remedying the error. Consequently the upward trend in non-ferrous metal consumption must be regarded as exaggerated (not necessarily over the whole period, because at the beginning of the series there could certainly have been little scrap used, but since scrap consumption became significant).

Textile Materials

2.19. The statistics for the remaining materials need less explanation. The *cotton* statistics represent deliveries to mills from 1851 to 1908 (taken from the *Fiscal Blue Book*, 1909 (17)). From 1909 to 1950 they represent actual consumption: to 1939 from returns made to the International Federation of Master Cotton Spinners' and Manufacturers' Associations; and from 1940 to 1950 from returns made to the Cotton Control and the Raw Cotton Commission.

2.20. The series for *wool* consists of retained imports and exports from the trade accounts (including alpaca, vicuna and llama wool, camels' hair and mohair, as well as sheep's and lambs' wool). Domestic production, the wool from imported woolled sheepskins and the supplies of recovered wool (shoddy, etc.) are taken up to the 1930's from the series of statistics of wool supplies compiled for many years by the Bradford Chamber of Commerce (4) which go back to 1775. They are then linked with the statistics compiled by the Imperial (now Commonwealth) Economic Committee, the Wool Control (for the war years and immediately after) and the Wool Industry Bureau of Statistics (since 1946). From 1940 the estimates of supplies available can be adjusted to give consumption figures from records of stocks. The figures used represent actual weight of wool as recorded: no attempt is made to correct the series on to a uniform basis of greasy or clean wool. Since wool yields (the proportion of clean wool that can be extracted from a given weight of greasy wool) have been tending to increase over the century, the use of actual weights, which represent greasy weight more closely than clean weight, may introduce some downward bias into the trend of the wool consumption series.

2.21. *Rayon* production is necessarily taken at the filament stage (for continuous filament rayon) less exports and plus retained imports of yarn thread and filament. The figures for *silk*, *jute* and *hemp* (which include also ramie and coir) are simply retained imports. For *flax* an estimate of home production (in terms of scutched flax) and exports has been added. Direct figures of flax production are available only from 1921 (apart from some estimates for 1909–13). For earlier years an estimate has been made from the acreages in the Agricultural Statistics which have been collected continuously from 1866. From 1921 to 1945, in spite of the fluctuations in acreage, there seems to have been no marked trend in the yield per acre, which has averaged about one-sixth of a ton of scutched flax per acre (since 1945, however, yields have greatly increased). For lack of other information I have therefore assumed a constant yield at this level for the whole period to 1920 (admittedly a hazardous hypothesis, since the acreage when the agricultural statistics began in 1866 was over 5 times as great as in 1920, and incidentally more than 5 times as much as it is now and more than one-third greater than the peak reached in World War II). If this estimate of yield is seriously in error, it could affect substantially the early series for flax, since in the 1860's we were producing about 40 per cent. of our consumption. By the end of the century, however, the proportion was only about 10 per cent. The statistics of available supplies of silk, hemp, flax and jute have been adjusted from 1940 for recorded changes in stocks.

Softwood

2.22. The net import figures for softwood correspond so far as possible with the current descriptions in the trade accounts: "hewn; sawn, not further prepared; planed or dressed"; plus sleepers. I have excluded pitwood, and would have excluded sleepers had they been separately stated throughout, since these categories are doubtfully "raw materials". In view of changes in classification in the trade statistics, there is naturally some doubt whether the import figures can be regarded as precisely comparable throughout. Up to 1935 the trade statistics for the main categories were given in terms of "loads". They have been converted to standards, the present unit of measurement for softwood, taking 1 load = 0·3 standards (2).

2.23. The main problem in this series is to estimate home production. Again, one must

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resort to the roughest of estimates for much of the period. There are detailed records for 1940 onwards, and special surveys were made, on a "sample" basis,* of home timber production in 1905, 1913/14, 1924 and 1930 by the Boards of Agriculture and the Forestry Commission (1). from these sources and from the Forestry Commission's report of 1943 on Post-War Forest Policy (8) (which gives an estimate of fellings during World War I), it appears that in 1905, and again in 1924, and 1930, home production on the definitions used for imports cannot have varied much from about 100,000 standards a year, except in World War I, when production rose to 1 million standards at the peak. It seems unlikely that the rate of output can have exceeded 100,000 standards before 1905, or that it reached this level before the late 19th century. A stable output of 100,000 standards from 1890 to 1939 has therefore been assumed, and the output before 1890 is ignored. Since total consumption had risen to about 1 million standards by the mid-1870's and exceeded 2 million standards in most years in the 1920's and 1930's, a fairly considerable error in the estimate of home production would not much affect the trend of consumption.

2.24. Stock changes have been allowed for from 1940, when they were first recorded. In view of the elements of doubt about home production, the classification of imports, and the conversion from other units into standards, the series for softwood consumption has been given only to two significant figures before 1940.

Rubber

2.25. The statistics are retained imports up to 1935, since when they are adjusted for recorded stock changes and production of waste and reclaimed rubber is added (from 1942).

Ireland

2.26. A final statistical point: all figures relate in principle to the United Kingdom. No allowance has been made for the separation of the Irish Free State in 1923. Consumption within the Irish Free State is included in the consumption figures before 1923, and excluded thereafter. This can hardly affect the trends shown, but it does in certain cases (flax, wool) affect the trend of the relationship between "home" production and imports discussed in *Part* 5.

3. *Input and Output Trends*

The Main Trends

3.1. The statistics of consumption of the raw materials for which estimates have been made are shown in Table 1 (Metals) and in Table 2 (Textile and Other Materials) in quantities and as index numbers. Annual averages only are shown, for trade cycles as described above (for annual figures see Appendix). The trends are summarized in Diagram 1, which is a crude way of illustrating the extraordinary divergence since World War I between the two main sectors of British manufacturing industry—the metal-using group of industries and the textile industries—measured by the total tonnage of metals and textile fibres consumed.

3.2. Up to the 1890's the two groups were advancing in step. A spurt at the turn of the century brought the metal-using group a little ahead, but they moved parallel again until World War I. During the whole period from 1850 to 1913 the rate of increase in absolute terms was almost linear in both groups.

3.3. World War I marked the turning-point. While the textile group moved slowly but steadily downwards, the consumption of metals was still rising (apart from the War and the post-war depression) at about the same absolute rate as in the previous half-century. The depression of the early 1920's brought an interruption, but the recovery of the late 1930's saw higher rates of both absolute and percentage increase in metal consumption. The figures bring out the radical and continuing change in the British economy.

3.4. The change in the tonnage of input in an industry or group of industries will not necessarily reflect accurately the extent of the change in the volume of output, as normally measured by production series which show movements in the value of gross or net output at constant prices. The productivity of raw materials will be affected both by the changing composition of output,

* The samples in 1924 and 1930 represented about 11 per cent. of the total woodland area, but appear to have been chosen by deliberate selection rather than at random.

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TABLE 1

Consumption of Raw Materials in Annual Averages, 1851–1950—*Metals*

(*a*) In Quantities

Thousand long tons

	Steel[a] (1)	*Iron Products* (2)	*Iron and Steel* (3)	*Copper*[b] (4)	*Zinc*[b] (5)	*Lead*[b] (6)	*Aluminium*[b] (7)	*Tin*[b] (8)	*Total Non-ferrous*[b] (9)	*Total Metals* (10)
1851–56	—	1,850	1,850	22	15	58	—	6	101	1,951
1857–63	55	2,350	2,405	21	20	62	—	8	111	2,516
1864–70	170	2,900	3,070	16	35	77	—	10	138	3,208
1871–77	480	3,550	4,030	21	48	108	—	14	191	4,221
1878–82	780	3,300	4,080	30	69	126	—	15	240	4,320
1883–90	1,020	2,850	3,870	30	85	134	—	17	266	4,136
1891–96	1,350	3,200	4,550	44	94	158	—	21	317	4,867
1897–1901	2,460	3,100	5,560	64	105	192	—	15	376	5,936
1902–06	2,760	3,250	6,010	64	127	208	—	18	417	6,427
1907–13	3,210	2,900	6,110	82	155	188	—	24	449	6,559
1914–18	5,430	2,350	7,780	185	137	186	—	25	533	8,313
1919–23	3,755	2,100	5,855	66	106	151	4	18	345	6,200
1924–28	5,180	2,450	7,630	131	177	252	17	23	600	8,230
1929–32	5,025	2,250	7,275	155	178	282	25	23	663	7,938
1933–36	6,300	2,100	8,400	237	191	308	27	9	772	9,172
1937–39	8,415	2,450	10,865	331	220	351	56	26	984	11,849
1940–44	10,595	2,250	12,845	689	352	305	226	30	1,602	14,447
1945–47	8,382	2,450	10,832	422	267	313	180	30	1,212	12,044
1948–50	10,100	3,350	13,450	397	281	329	197	30	1,234	14,684

(*a*) Consumption of finished steel (finished weight).
(*b*) Including secondary metal from 1933–36 (rough estimates through 1941). The figures refer to the consumption of finished metal.

For annual figures, see Appendix.

1(*b*) Index Numbers (1907–13 = 100) (Aluminium 1924–28 = 100)

	Steel (1)	*Iron Products* (2)	*Iron and Steel* (3)	*Copper* (4)	*Zinc* (5)	*Lead* (6)	*Aluminium* (7)	*Tin* (8)	*Total Non-ferrous* (9)	*Total Metals* (10)
1851–56	—	64	30	27	10	31	—	25	22	30
1857–63	2	81	39	26	13	33	—	33	25	38
1864–70	5	100	50	20	23	41	—	42	31	49
1871–77	15	122	66	26	31	57	—	58	43	64
1878–82	24	114	67	37	45	67	—	63	53	66
1883–90	32	98	63	37	55	71	—	71	59	63
1891–96	42	110	74	54	61	84	—	88	71	74
1897–1901	77	107	91	78	68	102	—	63	84	91
1902–06	86	112	98	78	82	111	—	75	93	98
1907–13	100	100	100	100	100	100	—	100	100	100
1914–18	169	81	127	226	88	99	—	104	119	127
1919–23	117	72	96	80	68	80	24	75	77	95
1924–28	161	84	125	160	114	134	100	96	134	125
1929–32	157	78	119	189	115	150	147	96	148	121
1933–36	196	72	137	289	123	164	159	38	172	140
1937–39	262	84	178	404	142	187	329	108	219	181
1940–44	330	78	210	840	227	162	1,329	125	357	220
1945–47	261	84	177	515	172	166	1,059	125	270	184
1948–50	315	116	220	484	181	175	1,159	125	275	224

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TABLE 2

Consumption of Raw Materials in Annual Averages, 1851–1950—*Textiles and Other Materials*

(*a*) In Quantities

Thousand long tons (except softwood)

	Cotton (1)	*Wool* (2)	*Rayon* (3)	*Silk* (4)	*Flax* (5)	*Total clothing fibres* (1–5) (6)	*Hemp, etc.* (7)	*Jute* (8)	*Total Textiles* (6–8) (9)	*Softwood (mn. stds.)* (10)	*Rubber* (11)
1851–56	346	109	—	2·38	115	572	39	23	634	·4	1·8
1857–63	368	129	—	2·76	115	615	42	42	699	·5	2·4
1864–70	391	168	—	1·54	117	678	46	83	807	·8	4·7
1871–77	551	212	—	1·50	108	873	54	153	1,080	1·1	5·9
1878–82	592	216	—	1·07	95	904	53	185	1,142	1·1	6·8
1883–90	668	238	—	1·11	85	992	55	221	1,268	1·3	7·5
1891–96	712	291	—	0·76	82	1,086	57	219	1,362	1·6	9·2
1897–1901	749	305	—	0·73	75	1,130	61	209	1,400	2·1	12·2
1902–06	761	300	—	0·46	71	1,132	73	242	1,447	2·1	11·8
1907–13	866	369	1	0·45	81	1,317	85	219	1,621	2·0	19·6
1914–18	809	392	1	0·61	72	1,277	95	180	1,552	1·5	27
1919–23	624	361	5	0·37	29	1,020	69	147	1,236	1·6	38
1924–28	678	284	14	0·46	37	1,013	76	180	1,269	2·0	34
1929–32	514	338	21	0·77	35	909	74	149	1,132	1·9	98
1933–36	568	353	41	1·87	38	1,002	91	162	1,255	2·6	111
1937–39	560	370	53	2·43	44	1,030	109	157	1,296	2·2	125
1940–44	421	245	49	0·70	33	749	102	104	955	0·86	151
1945–47	332	256	62	0·36	33	683	88	85	856	1·02	198
1948–50	428	367	116	0·68	39	951	102	98	1,151	1·20	242

(1) Raw cotton used in cotton spinning only.
(2) In actual weight. Includes sheep's and lambs' wool; wool from imported woolled sheepskins; alpaca, camels' hair, mohair; shoddy and other recovered wool.
(3) Includes nylon and other synthetic fibres.
(4) Imported raw silk.
(5) In terms of scutched flax.
(7) Includes hemp, ramie, coir and similar fibres.
(10) Excluding pitwood, including sleepers.
(11) Including gutta-percha, balata, waste and reclaimed rubber and synthetic rubber.

For annual figures see Appendix.

2(*b*) Index numbers (1907–13 = 100) (Rayon 1924–28 = 100)

	Cotton (1)	*Wool* (2)	*Rayon* (3)	*Silk* (4)	*Flax* (5)	*Total clothing fibres* (1–5) (6)	*Hemp* (7)	*Jute* (8)	*Total Textiles* (6–8) (9)	*Softwood (mn. stds.)* (10)	*Rubber* (11)
1851–56	40	30	—	529	142	43	46	11	39	20	9
1857–63	42	35	—	613	142	47	49	19	43	25	12
1864–70	45	46	—	342	144	51	54	38	50	40	24
1871–77	64	57	—	333	133	66	64	70	67	55	30
1878–82	68	59	—	238	117	69	62	84	70	55	35
1883–90	77	64	—	247	105	75	65	101	78	65	38
1891–96	82	79	—	169	101	82	67	100	84	80	47
1897–1901	86	83	—	162	93	86	72	95	86	105	62
1902–06	88	81	—	102	88	86	86	111	89	105	60
1907–13	100	100	7	100	100	100	100	100	100	100	100
1914–18	93	106	21	136	89	97	112	82	96	75	138
1919–23	72	98	36	82	36	78	81	67	76	80	194
1924–28	78	77	100	102	46	77	89	82	78	100	173
1929–32	59	92	150	171	43	69	87	68	70	95	500
1933–36	66	96	293	416	47	76	107	74	77	130	566
1937–39	65	100	379	540	54	78	128	72	80	110	638
1940–44	49	66	350	158	41	57	120	47	59	43	770
1945–47	38	69	443	80	41	52	104	39	53	51	1,010
1948–50	49	99	829	151	48	72	120	45	71	60	1,235

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TREND OF CONSUMPTION OF METALS AND TEXTILES
1851 – 1950

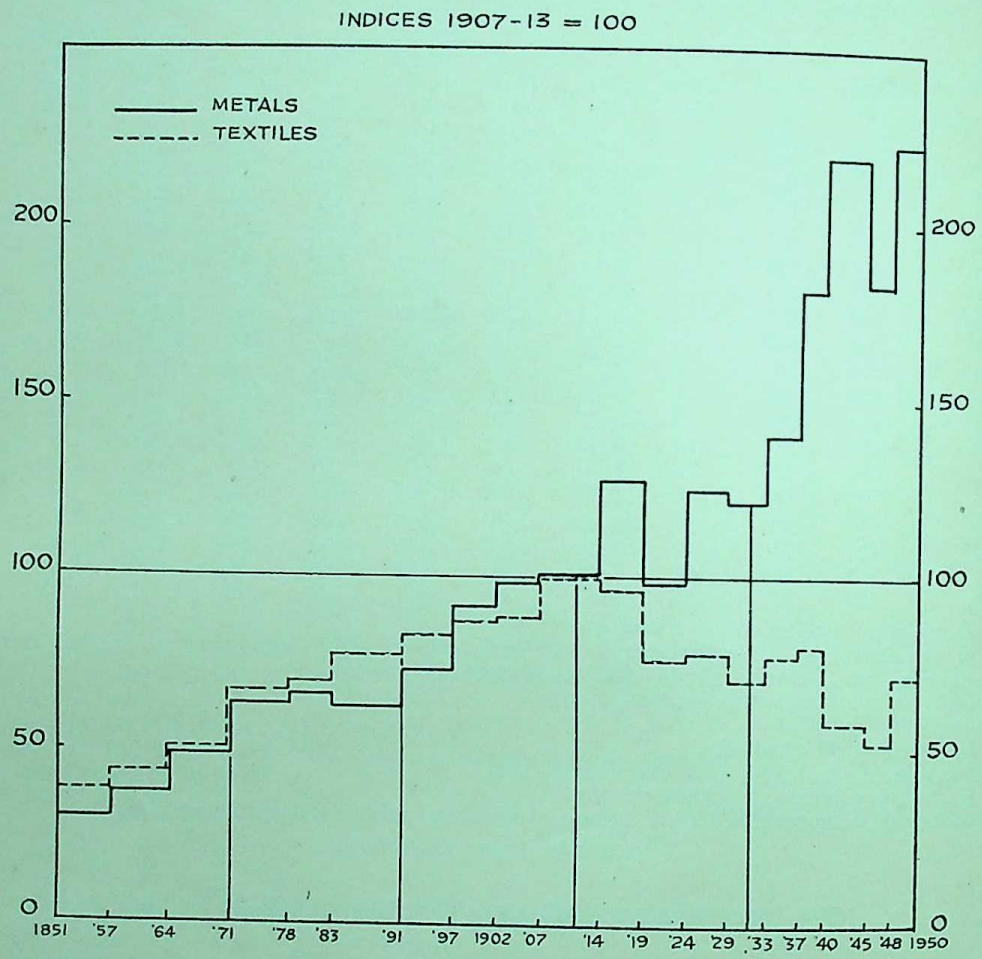

DIAGRAM 1

and by technical factors such as the substitution of light for heavy materials (e.g., steel for iron or aluminium for steel).

3.5. This part of the paper is devoted to an attempt to measure the change in productivity of materials, using as measures of output the changes in volume of output shown by the censuses of production from 1907 to 1935, supplemented by indexes of production from 1935 to 1950. It is important for this purpose to use census of production data so far as possible, because most indexes of production are themselves based to a greater or less extent on input series; this applies particularly to such indexes of production as have been compiled for the period before World War I. The trends in the metal-using and textile groups will be dealt with separately.

Input and Output in the Metal-using Industries 1924–35

3.6. The longest period at present susceptible to detailed examination is that between the 1924 and 1935 censuses of production. The available information about metal consumption and the volume of output in the metal-using industries is brought together in Table 3.

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TABLE 3

Comparison of Metal Consumption with Volume of Output in the Metal-using Industries

	Indexes (1924 = 100)			*Quantities* ('000 *tons*)		
	1924	1930	1935	1924	1930	1935
Metal Consumption						
Steel	100	111	131	4,890	5,425	6,415
Iron products[1]	100	92	80	2,630	2,430	2,100
Copper	100	131	232	122	160	283
Zinc	100	128	131	156	200	204
Lead	100	137	141	218	299	307
Aluminium	100	214	200	14	30	28
Total non-ferrous (exc. tin)	100	135	161	510	689	822
Total metals	100	106	116	8,030	8,544	9,337

	Index of gross output at 1935 prices (1924 = 100)			*Value of net output at 1935 gross output prices* (£ *million*)		
	1924	1930	1935	1924	1930	1935
Volume of Output of Principal Products						
Mechanical engineering	100	103	113	87·0	90·0	98·0
Electrical engineering	100	122	182	31·5	38·4	57·3
Shipbuilding (private firms)	100	95	58	27·2	25·9	15·9
Motor and cycle	100	145	238	27·1	39·4	64·4
Aircraft	100	275	425	2·0	5·5	8·5
Railway carriage and wagon (private companies)	100	70	72	5·7	4·0	4·1
Carriage, cart and wagon	100	87	73	1·5	1·3	1·1
Total engineering, ship-building and vehicles	100	112	137	182·0	204·5	249·3
Hardware, holloware, etc.	100	142	196	9·2	13·1	18·0
Chain, nail, screw[2]	100	112	129	4·1	4·6	5·3
Tools and implements	100	106	153	3·2	3·4	4·9
Cutlery	100	140	240	1·0	1·4	2·4
Needles, pins, metal smallwares	100	100	117	1·8	1·8	2·1
Small-arms (private firms)	100	60	60	·5	·3	·3
Plate and jewellery	100	88	90	5·1	4·5	4·6
Watch and clock	100	200	700	·1	·2	·7
Total metal-using trades (1935 net output weights)	100	113	139	207·0	233·8	287·6
Building and civil engineering	100	131	154			
Total[3]	100	115	141			

[1] Because of the method of computation, the figures for 1924 and 1930 are unreliable in themselves, and averages for 1923–25 and 1929–31 respectively are substituted.
[2] Allocated only half its actual net output to allow for duplication with other industries in the table.
[3] Weighting Building 1 to Metal-using 9 (roughly proportionate to metal usage).

3.7. It is of course difficult to make clear-cut comparisons for individual years between input and output volumes, but there is no real choice, because no adequate output data exist for other years. On the input side the consumption figures for a particular year calculated from available supplies are liable to distortion by stock changes. Further, there is the substantial time lag, especially in parts of the engineering trades, between the first processing of the raw materials and the output of the finished product. However, since both 1924 and 1935 were on rising curves of output, the effect of both these factors may be small, although not much confidence can be

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put in the figures for 1930 when output was declining. There is a check on the steel consumption figures from estimates made by the British Iron and Steel Federation, on the basis of the censuses, of actual steel consumption in 1924, 1930 and 1935. The trend of these figures agrees closely with that of my estimate of available supplies.* There seems no particular justification, in this comparison, for seeking to improve the input estimates by averaging over longer periods.

3.8. The second problem on the input side is to consider whether any suitable weighting can be found for the separate metals. Since the use of nearly all the metals is widely spread over nearly all the industries concerned, there seems to be no sensible way of computing separate average values added per ton of each metal used. It is, however, the case that the major uses for copper and lead are in electrical engineering, where the proportion of steel to total metals used is least (this is shown by the statistics reported in the census of 1935 for materials actually used in the various metal-using industries). Further, the net output per ton of all metals used (in 1935) is substantially greater in electrical engineering (about £120 per ton) than in the main steel-using industries (mechanical engineering, £60 a ton; shipbuilding and repairing with marine engineering, £30 a ton) other than motors, cycles and aircraft (£150 a ton). It seems at first sight reasonable to suppose that any weighting system would give a lower weight per ton to steel than to the average for the non-ferrous metals. The effect would be to increase somewhat the rise in input between 1924 and 1935 (since steel input rose less than the non-ferrous metals). Unless steel was given a very small weight per ton, however, the introduction of weights could not greatly affect the result.

3.9. In the measurement of output, there are the familiar and insoluble weighting problems. The indexes of volume of output for the various metal-using industries shown in Table 3 are taken from the Final Reports of the 1935 Census. The volume index for each trade represents the *gross* output in 1924, or 1930, at 1935 gross output prices. The trades are combined in the table be using as weights 1935 *net* outputs, since it is net output that we really want to measure. For convenience, the time base has been shifted to 1924.

3.10. The effect of using base year (1924) net output weights instead of end-year (1935) weights for each trade would be, as usually happens in these calculations, to increase the rate of expansion shown over the period. Thus the volume of output in the engineering, shipbuilding and vehicle group is shown, on 1935 weights, to rise from 100 in 1924 to 137 in 1935. If the volume increases were applied to 1924 net outputs of each trade, the combined index would rise from 100 to 150. The difference might well be increased if it were possible to use net output weights for each of the products within each trade.

3.11. The output series include all the principal metal-using industries now included in Orders VI to IX of the Standard Industrial Classification. Building is also shown. Since it would be inappropriate to combine building with the metal-using trades on a basis of relative net outputs, it is brought in to the estimate of total output with a weight of one-tenth, roughly proportional to the tonnage of metals used. Building probably used in 1935 under a tenth of the total steel and rather more of the copper consumption, but perhaps half the zinc and a third of the lead.

3.12. Some clear connections can be traced from Table 3 between output in particular industries and the use of particular metals. The larger than average increase in *copper* consumption can reasonably be associated with the greater than average rise in electrical engineering, which accounted for over half the total copper consumption in 1935; the increase, however, seems greater than can be explained by this factor alone, and suggests extensive substitution of copper for other metals in other uses. The trend in *lead* is interesting. The two main uses are in electrical engineering (cable covering and to a much less extent batteries) and in building, the former probably taking the larger amount in 1935. Both these consuming industries increased their output more than average between 1924 and 1935, by over 80 per cent. and by a half respectively. Yet lead consumption rose only 40 per cent. The contrast is even more striking between 1930 and 1935. How far this is due to economy in usage, how far to technological change cannot be ascertained. For *zinc* the main single use is in building. As with lead, the increase in zinc consumption from 1924 to 1935 (one-third) was significantly less than the rise in building output.

* *British Iron and Steel Federation Monthly Statistical Bulletin*, July 1950. The B.I.S.F. figures for consumption are (as indexes with 1935 = 100): 1924—75; 1930—84; my estimates give: 1924—76; 1930—85.

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3.13. It will be shown below that after 1935, changes in relative prices played a large part in the divergencies between the consumption trends in the different metals. During 1924–35, this factor cannot have been of major importance, the changes in relative prices being comparatively small.*

3.14. The estimates of input and output may now be compared, bearing in mind the qualifications above. From 1924 to 1935 total metal consumption in tonnage rose by 16 per cent. Meanwhile net output (1935 weights) in the main metal-using industries other than building rose by almost 40 per cent., and in building by over 50 per cent. The combined increase in output is put at 41 per cent. Thus the "productivity" per ton of metals rose by 22 per cent. on 1935 weights and perhaps by nearly 30 per cent. on 1924 weights. There is some suggestion in the figures that the rise in productivity was rather more marked in 1930–35 than in 1924–30; but the figures for 1930 cannot be regarded as very reliable, because the fall in output during the year may well have distorted the input-output relationship.

3.15. This rise in the productivity of metals between 1924 and 1935 may have been due either to a shift in the composition of output from heavy to light products (i.e., from products using much metal in relation to net output to those using less), or to the use of a smaller weight of metal in the production of a given product. A rough indication can be got of the relative importance of these two influences. If the outputs of the separate metal-using industries shown in Table 3 are weighted, not by net outputs (as in Table 3) but by the total tonnage of metals used in each industry in 1935, the combined increase in output from 1924 to 1935 is not 41 per cent. but only 25 per cent.† This means that if *within each industry the* input-output relationship had remained constant from 1924 to 1935, the rise in output being no greater than the rise in tonnage of raw material input, total output of the metal-using and building industries would have risen only 25 per cent. The rise in productivity of metals (input rising 16 per cent.) would have been only 8 per cent.

3.16. Of the total rise in productivity of 22 per cent., therefore, a rise of 8 per cent.—say one-third—may be ascribed solely to the shift in the relative importance of the various metal-using industries. The major elements in this change in composition were:

(*a*) the reduction in the output of shipbuilding by over 40 per cent., shipbuilding being a heavy user of metals in proportion to net output;

(*b*) the greater than average rise in the output of electrical engineering (over 80 per cent.) and in the motor and cycle industry (140 per cent.), both being light users of metals in proportion to net output.

All this confirms the general impression of the shift from "heavy" to "light" engineering during the inter-war years as a result of the development of new industries—motors, aircraft and important branches of electrical engineering.

3.17. The remaining two-thirds of the rise in the productivity of metals must therefore be attributed to increasing productivity within the individual metal-using industries—in one sense to "economy" in metal usage. This again can take more than one form. In part, it is substitution of light metals for heavy: of steel for iron, of aluminium for steel, of other metals for lead (as suggested in paragraph 3.12), the object being to get lighter, or smaller, products without loss of strength or efficiency. It is, for example, reckoned that a ton of aluminium sheet will cover 2½ times the area of a ton of steel sheet. If the admittedly rather doubtful figures of consumption of iron products are to be trusted (see Table 3), the biggest single factor of this kind must have been the substitution of steel for iron. Secondly, increasing productivity of metals may have taken the form of a greater degree of processing per ton of a given metal because of increasing elaboration of the final product. Finally, of course, there may be reductions in the weight of products which represent a definite loss of strength or durability.

3.18. It is, of course, impossible for indexes of output volume to take full account of changes in the nature of a finished product; much of the process of refinement or elaboration of a product

* From 1924 to 1935 the Board of Trade wholesale price index for iron and steel fell by about 23 per cent. Prices of unwrought copper, lead and zinc fell by approximately a half, but the prices of finished products probably fell less (e.g., brass sheet prices fell less than 30 per cent.).

† The weights are very rough and are based on Census of Production 1935, supplemented, for steel, by estimates of steel usage in the *British Iron and Steel Federation's Monthly Statistical Bulletin* July, 1950.

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of a given description is missed by the estimates of output volume, whether compiled from censuses of production or from other physical production statistics. The true increase in net output per ton of input may therefore be greater than is shown by the estimates used here, since part of it may appear as a rise in net output prices and not as an increase in output volume.

Input and Output in the Metal-using Industries since 1935

3.19. Comparisons of output with input before and after 1924–35 cannot at present be studied with even the attempt at precision made in the preceding paragraphs. A much more accurate and interesting comparison of the changes between 1935 and 1948 will of course be possible when the results of the 1948 census become available and when the interim index of production, with its provisional 1946 weights, can be re-weighted in the light of the census.*

3.20. At present only very rough guesses for the period since 1935 are worth while. As regards *output* the very tentative computations of the Central Statistical Office suggest a rise in output in the metal-using industries (Orders VI–IX) between 1935 and 1946 of some 25–30 per cent. (7), and a fall in building and civil engineering output of some 20 per cent. The London and Cambridge Index gives a similar result for "engineering, shipbuilding and vehicles", but a fall of over 30 per cent. for building (including building materials) (6). The combined increase in the metal-using and building industries† from 1935 to 1946 would be about 25 per cent. By 1950, on the Central Statistical Office Interim Index of Production for 1946/50, output in the metal-using industries was about double that of 1935, while building was about equal—say a rise of about 90 per cent. in total.†

3.21. Meanwhile, the increases in input of metals have been:

TABLE 4

Consumption of Metals 1935–1950

	'000 *tons*			*Percentage increase*	
	1935	1946	1950	1935 *to* 1946	1935 *to* 1950
Steel	6,415	8,101	10,500	26	64
Iron products	2,100	2,600	3,400	24	62
Copper	283	367	422	30	49
Zinc	204	252	303	24	49
Lead	307	317	330	3	8
Aluminium	28	173	230	516	720
Total	9,337	11,810	15,185	26	63

3.22. Over the eleven years 1935 to 1946, therefore, both input and output are shown to increase by about one-quarter, with no change in the average productivity of metals. This comparison may, however, be misleading. The changes in the volume of output are based principally on statistics of deliveries of finished goods. In 1946 the economy as a whole, and the engineering industries in particular, were still in the process of reconversion, and the ratio of finished output to work done may well have been abnormally low. In such a period we would not expect to find a significant relationship between input and output of finished goods.

3.23. More significant is the comparison between 1935 and 1950. Over this period output in the metal-using industries and building rose by about 90 per cent. and input of metals by 63 per cent. The rise in productivity of metals was thus about 17 per cent.—rather less in these fifteen years than the rise of 21 per cent. in the eleven years 1924 to 1935. Bearing in mind the qualifications on the 1946 figures it looks, however, as though most of the increase in 1935 to

* The figures given in the paper are based on the Interim Index of Production. The revised index (1948 weights), which became available after the paper was read, does not necessitate any significant changes in the figures.

† Weighting building 1 to 9 for the other industries, as above. (On 1950 weights, the relative importance of building, in terms of metals used, might be nearer 1½ to 8½.)

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1950 occurred after the war. This is shown by Table 5. The figures for individual years are not very reliable, but they are consistent enough to suggest a fairly rapid and continuous increase in the productivity of metals in recent years. If it can be assumed that by 1948 output of finished goods had caught up with the expansion in work in progress, then, on the figures in Table 5, there was an increase of about 5 per cent. in the productivity of metals in each of the years 1949 and 1950.

TABLE 5

Output of the Metal-using Industries and Building, and Consumption of Metals 1935–50

	1935	1946	1947	1948	1949	1950
Total metal consumption						
'000 tons	9,337	11,810	13,109	14,075	14,651	15,185
1935 = 100	100	126	140	151	157	163
Output (1935 = 100)						
Metal-using industries	100	130	147	168	183	200
Building and civil engineering	100	79	87	96	100	105
Total	100	125	140	160	175	190

3.24. For the inter-war period, we found that about one-third of the increase in productivity could be attributed to the change in composition of the metal-using industries from the heavy to the light users of metal. This explanation does not seem to apply to the rise in productivity over the whole period 1935–50. A rough weighting of the increase in output of the main metal-using industries by the amount of metal consumed in each (in 1948) yields almost exactly the same increase in the total output of the group as a weighting by net outputs. The reason seems to be that although the expansion of output was less than average in shipbuilding, the major heavy metal user, it was also less than average in the motor and cycle industry, one of the main light metal users.

3.25. The interesting feature of the last 15 years is the disproportionately small rise in usage of non-ferrous metals, other than aluminium. The very small increase in lead usage may in part be explained by the fact that building activity is no greater than before the war, and the building of new houses in particular has been less than two-thirds of the pre-war level (200–230,000 a year in 1948–50 compared with 350–370,000 in 1935–39). On the other hand the expansion of electrical engineering, the other main outlet for lead, might have been expected to offset the fall in building usage. Yet lead consumption in electrical engineering has increased very little. There are clear indications, as there were for the period 1924–35, of the tendency to replace lead by other materials.

3.26. The expansion of aluminium usage is spread over a variety of outlets. In 1948 the major users, each accounting for 10–25 per cent. of total consumption, were hollow-ware and metal furniture, motor vehicles, constructional engineering (including pre-fabricated houses), electrical engineering, mechanical engineering, and aircraft. Electrical engineering, in spite of the recent developments of the use of aluminium cable in the place of copper, used comparatively little. The incidence of aluminium expansion seems therefore to have fallen on steel rather than on the other non-ferrous metals.

3.27. These changes in relative consumption cannot easily be explained simply by post-war supply shortages. For most of the post-war period (until the end of 1950, when various rationing schemes came into operation) there was no effective restriction on the purchases of non-ferrous metals from the Ministry of Supply. On the other hand, steel allocation was still in force until early 1949.

3.28. A major incentive to economy in the use of the older non-ferrous metals can be found in the course of relative prices. By 1950, copper, lead and zinc prices were all between 6 and 9 times as much as in 1935 (these are prices of unwrought metal and the price to the final user may not have increased so much). Over the same period aluminium prices had risen comparatively little (they were indeed reduced by 40 per cent. in 1945 and 1946; but raised again later) and steel prices had approximately doubled. During the post-war period, also, there is the same disparity

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in relative price movements. From 1946 to 1950 copper, lead and zinc prices about doubled, while aluminium and steel prices rose by between a quarter and a third. Meanwhile, there was no evidence of a continuously rising trend in copper, lead or zinc consumption, but aluminium and steel consumption were both rising steadily and fast.

Input and Output in the Metal-using Industries 1907–1924

3.29. It is worth while to look back now at the changes between the 1907 and 1924 censuses of production, although comparison of output over this period is rendered difficult by the lack of quantitative output data in the 1907 census. A rough estimate has, however, been made by Tolles and Douglas of the increase in volume of output between 1907 and 1924. (6) They show a rise in the combined output of the iron and steel, engineering, shipbuilding and vehicle trades between 1907 and 1924 of about 50 per cent.* Building output meanwhile is estimated to have risen only 20 per cent., showing a combined increase of, say, 45 per cent.

3.30. The changes in metal consumption were as follows:

TABLE 6

Metal Consumption 1907–24

	'000 *tons*		
	1907	1924	*Percentage change*
Steel	2920	4890	+67
Iron products[1]	2800	2630	−6
Copper	66	122	+85
Zinc	134	156	+16
Lead	181	218	+20
Aluminium	—	14	..
Total	6101	8030	+32

[1] averages of 1906–8 and 1923–25

3.31. Over this period, therefore, the rise in productivity of metal input appears fairly modest —of the order of only 10 per cent. over 17 years. A large part of this small increase in productivity in 1907–24 may be explained by the continuing substitution of steel for iron. The other striking features are (*a*) the greatly expanding use of copper, which may be traced to the development of electrical power; (*b*) the comparatively small rise in zinc and lead consumption; this may be connected with the equally small rise in building output—since during most of this period the building trade must have accounted for the bulk of zinc and lead consumption—but a somewhat larger rise in lead usage might have been expected as a result of electrical development.

3.32. It does not appear that relative prices were responsible during this period for the shifts in consumption, except that the expanding use of copper was associated with a fall, between 1907 and 1924, of more than a quarter in the price. But steel prices seem to have risen possibly more than lead prices, and certainly more than zinc prices.† In this period the changing pattern of industrial development appears as the main factor.

Metal-using Input and Output: Summary

3.33. The changes in metal input and in output of the metal-using industries and building may now be drawn together to give a general view of the trends.

* Fisher "ideal" index, based on geometric mean of results based on 1907 and 1924 weights respectively. The indexes were combined, in the case of the metal-using industries, by deflating the increase in gross output values by an independently estimated index of metal prices.

† The Board of Trade wholesale price index for iron and steel rose 43 per cent. between 1913 and 1924, and there was some further increase between 1907 and 1913. Prices of finished steel seem to have risen rather more. From the Censuses of Production 1907 and 1924 it appears that the average value of U.K. production rose about 70 per cent. for plates and sheets (not galvanized), 50 per cent. for galvanized sheets, over 40 per cent. for railway rails. Average value of ingots, however, are shown to have risen only 30 per cent., and of blooms, billets and slabs 50 per cent. The rise in lead prices between 1907 and 1924 was 72 per cent., and in zinc prices 42 per cent. (*Quin's Metal Handbook*, 1950, p. 266).

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TABLE 7

Metal-using Industries: Input and Output 1907–50

Percentage Change within each Period

	1907 *to* 1924	1924 *to* 1935	1935 *to* 1950
Output of metal-using industries and building .	+45	+41	+90
Consumption of metals	+32	+16	+63
Productivity of metals per ton	+10	+22	+17

3.34. In Table 8 the indexes are linked to give a continuous series. These figures are reproduced in a scatter diagram (Diagram 2). The diagonal on the chart represents constant productivity.

TABLE 8

Linked Indexes of Metal-using Industries, Input and Output 1907–50

1935 = 100

	1907	1924	1930	1935	1948	1949	1950
Output							
Metal-using industries . . .	48	72	81	100	168	183	200
Building	54	65	85	100	96	100	105
Total	49	71	82	100	160	175	190
Consumption of metals . . .	65	86	91	100	151	157	163
Productivity of metals per ton . .	75	83	90	100	106	111	117

3.35. The annual rate of increase in productivity has thus varied considerably—much less than 1 per cent. a year over the whole period 1907–24; under 2 per cent. a year in 1924–35 but possibly more in the later years of this period; about 1 per cent. a year over the whole period 1935–50, but probably less than this until "reconversion" was completed, and apparently greater during the period 1948–50. The increase in the productivity of metals is no doubt in part a function of time, proceeding steadily with technical advance. But the more interesting point is the connection between the variations in the rates of increase in productivity and the variations in the rate of increase of total output. There is not, over the period as a whole, any close connection between productivity changes and changes in total output. But if the figures for the last 15 years are to be trusted (and it must be emphasized again that they are uncertain), they suggest that although there was little increase in productivity between 1935 and 1948, despite the substantial rise in output, yet in 1948–50, when output was rising very fast, productivity was increasing faster than at any other time for which there is evidence. A similar connection between changes in productivity and changes in total output is of course familiar from studies of labour productivity. The suggestion is that both labour productivity and raw material productivity are in large part a function of the degree of pressure on producers.

Input and Output in the Textile Industries

3.36. Comparisons of input and output for 1924–50 are given in Table 9. In the textile group it is, at least, possible for the most part to attach specific materials to their appropriate industries. In total, between 1924 and 1935, and especially between 1930 and 1935, the results show a slight and probably not significant increase in productivity per ton, probably due chiefly to the shifting balance between the various industries. In particular, cotton declines while wool expands (each carrying about 30 per cent. of the total weight), and during this period net output per ton was much greater in wool than in cotton (chiefly, no doubt, on account of the extremely low profitability of the cotton industry in the inter-war years). The contrast is, it is true, somewhat

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INPUT AND OUTPUT IN THE METAL USING INDUSTRIES

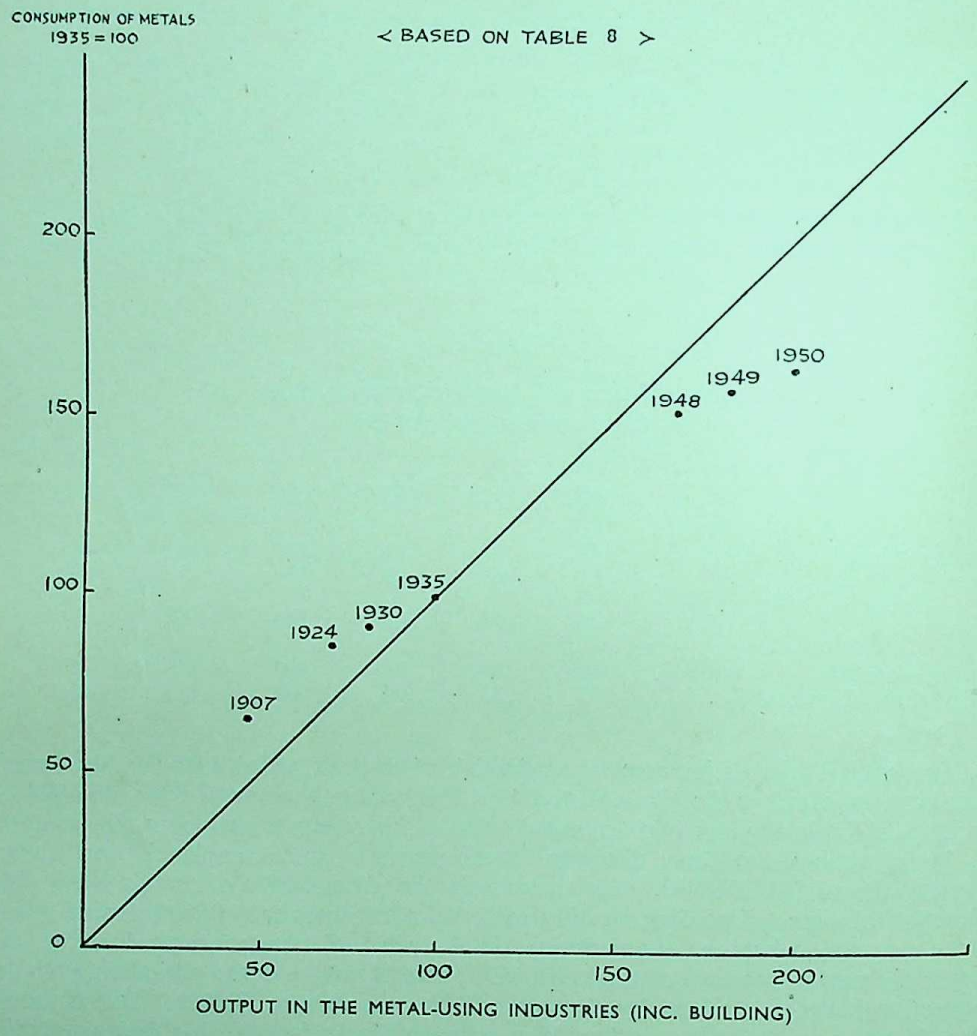

DIAGRAM 2

exaggerated by the fact that the decline in the "cotton" industry was in part the result of cotton-weaving firms going over from cotton to rayon.

3.37. The results for the individual industries are very mixed (and incidentally affected in part by imports and exports of yarn). The cotton figures suggest at first sight a substantial loss of productivity per ton. But a rough adjustment for the combination in fact, though not in the statistics, of the cotton and rayon-weaving industries, shows that this is largely a result of the necessarily arbitrary classification system.* In wool, also, there seems to be some loss of net output per ton of input. Productivity per ton of cotton may well have fallen since 1935, as a result of the shift from high to low counts of yarns. But this is due, not to any technological

* Add the input of rayon to the input of cotton. For output add the "silk and rayon" index to the cotton index (giving only half its full weight to the former to represent the rayon weaving net output). We then get:

	1924	1930	1935
Output	112	81	100
Consumption	110	75	100

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TABLE 9

Comparison of Textile Fibre Consumption with Volume of Output in the Textile Industries

Trade	*Volume of output* (1935 = 100) 1924	1930	1935	1950	*Fibre*	*Fibre consumption* (1935 = 100) 1924	1930	1935	1950
Cotton spinning and weaving	128	87	100	..	Cotton	117	78	100	77
Woollen and worsted	92	70	100	..	Wool	83	93	100	111†
Silk and rayon	20	47	100	..	Silk and rayon	27	38	100	295
Linen and hemp	101	82	100	..	Flax and hemp	92	83	100	112
Jute	102	82	100	..	Jute	112	84	100	69
Total all textiles	97	78	100	105*	Total (tonnage)	100	82	100	98

Volume of output indexes for the individual textile industries are from *Final Report of Census of Production*, 1935, Part I, p. 7. (Cotton spinning and weaving are combined with equal weights, since their net outputs were equal in 1935.) The all-textiles index (including other textile industries not specified, but excluding hosiery) is based on the same source, the industry indexes being weighted by their net outputs in 1935.

* 1935 to 1946 link from reference (7). 1946–50 from Central Statistical Office interim index of Industrial Production.

† Wool consumption in 1950 was abnormally high in relation to the output of the wool textile industry because of the exceptionally large output of tops for export.

deterioration, but to a shift in the balance of demand between different uses (e.g., loss of the export market for high count yarns, expansion of industrial uses for heavy products; the influence of the utility scheme).

3.38. Since 1935 there appears to have been a significant gain in the productivity of textile raw materials as a whole. This seems to be due again to the decline in cotton, which never recovered from the drastic concentration enforced during the war, while wool and rayon have on balance continued to expand. But if cotton and rayon are treated as a single industry (apart from filament rayon production), the contrast between Lancashire and Yorkshire would be much less striking.

3.39. The total change in the productivity per ton of textile materials over the whole period 1924–50 is therefore only about 10 per cent. (compared with about 45 per cent. in the metal-using industries). The kind of change experienced in the textile industries is predominately the shift in composition between trades. It is thus analogous with the shift from heavy to light metal-using trades which, as we saw (paragraph 3.16), accounted for only a minor part of the total rise in productivity per ton of metals.

3.40. No index of the changes in volume of output in the textile industries between 1907 and 1924 has been compiled. Tolles and Douglas combine textiles with clothing, showing almost no change in the volume of output of the two groups together. This is a strange result, since the consumption of every one of the textile raw materials (except rayon and hemp) declined, most of them drastically. The total tonnage of consumption fell indeed by about one-quarter. In view of the great loss of exports which brought about the collapse in output, it is of course quite possible that more cloth was available for the clothing industries, and more yarn for hosiery.* Also the lost export trade was chiefly in the cheaper qualities, so that average conversion values may well have increased, an increase which might be reinforced by the reduction in average weight of clothing brought about by fashion changes. But it hardly seems conceivable that rising clothing output or increases in productivity per ton should convert a 25 per cent. decline in input into more or less stationary output. The discrepancy may be explained by the much greater completeness of the 1924 census in respect of the clothing trades. The returns to the 1907 census in respect of the clothing group† covered 624,000 persons, but the editors of the Census (pages

* The supply of cloth available for the clothing industry cannot be measured from the Census with any exactness, but suggests a significant increase.

† Omitting laundries, etc., for comparison with 1924.

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391–2) estimate, from Census of Population data, that something like 400,000 persons, mostly working on their own or in small establishments, were not accounted for. In 1924 the Census return (which applied, on this occasion, only to establishments employing more than 10) covered 474,000 persons, and the estimated number employed in small firms was a further 149,000. If no allowance were made by Tolles and Douglas for the missing 400,000 in the 1907 Census, it is easy to see how the volume of output from textiles and clothing together might appear to remain stable from 1907 to 1924.

3.41. The fall in input of one quarter undoubtedly gives a somewhat exaggerated view of the fall in the volume of net output. Much of the decline was accounted for by the loss of most of the export trade in cotton piece goods to India—mainly goods with a very low conversion value. In 1924 a substantially larger *proportion* of the input passed through the processes of finishing and making up. It seems probable that the volume of output fell, but significantly less than the tonnage of input.

3.42. Apart from these exceptional circumstances, which make the 1907–1924 link very insecure, it seems justifiable to regard input trends in the textile industry as a whole as an approximate measure of output. Some improvement might be introduced by weighting the different textiles by their respective net outputs per ton. So far as can be seen from the 1907 Census, net output per ton was about equal in the cotton, wool and flax and hemp trades; it was much less (perhaps only a quarter as great) in jute, and probably somewhat more in silk. These relative weights can change a good deal (net output per ton in wool was about twice as great as in cotton in 1934–35, but cotton caught up again in 1948), and there is no particular justification for applying the 1907 weights to earlier periods. No adjustment has therefore been attempted.

3.43. An additional gain in the productivity of textile materials during the years 1924–35 would be apparent if the net output of the clothing trades were brought into account. The volume of output in these trades (tailoring, dressmaking, millinery, shirts etc.) moved as follows:

1924	1930	1935	1946	1950
79	87	100	77	98

(Sources: Census of Production 1935 for 1924–35; Central Statistical Office estimates (reference 7) for 1935–46; Central Statistical Office Interim Index of Production for 1946–50.)

If combined on the basis of relative net outputs in 1935, total textile and clothing output would be shown to increase between 1924 and 1950 by rather more than 10 per cent., while textile input, as shown in Table 9 was almost unchanged. All this increase in productivity took place before 1935.

4. *The Long Term Trend of Raw Material Input*

4.1. The material collected here, showing consumption of metals, textiles, rubber and softwood, is far from complete in its coverage of the input of industry. It represents fairly adequately the materials used in the metal-using and textile industries, which together accounted for rather more than half of the total net output of manufacturing industry (excluding building, and building materials), in 1907, 1924 and 1935, and for two-thirds in 1948. It covers some of the important materials used in building, but omits many more. The major sectors of manufacturing industry which these series fail to represent at all are chemicals (except in so far as progress in one of the biggest branches of the chemicals industry—dyestuffs—is largely bound up with the textile industries), paper, leather, and, of course, food, drink and tobacco manufacturing.

4.2. An attempt is, however, made in Table 10 to extract from the series a combined index of raw material consumption designed to show the general trend of input in the manufacturing industries using these materials. Each group of materials is given a weight proportional to the estimated relative net output in manufacturing* industry per ton of the relevant materials used. If there is no change in productivity of input the resulting series would represent the change in net output volume. The weights, which are necessarily very rough, are based on the net outputs per ton of input shown in the censuses of production 1907, 1924, 1935 and 1948. The net output per ton in the metal-using industries (excluding building) is taken as 1 throughout. In the 1907 census, it appears that net output per ton in the textile and clothing industries was about 5 times

* Manufacturing, in this sense, excludes the production of the material itself, e.g., steel manufacture.

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as great as in metal-using; thus each ton of textile input is given a weight of 5 up to the 1914–18 war. The 1924 census, however, showed a rise in net output per ton of textiles to 7 times that per ton of metals (due no doubt to the changes in textile markets and production described above). After 1914–18, therefore, textiles are given a weight of 7 per ton. Similarly calculated weights are applied to softwood and rubber, which are introduced into the combined series up to World War II. Softwood is, however, left out in 1940–44 and thereafter. The low level of softwood consumption in the past 10 years—at only half the amounts used in 1933–39 (the period of the building boom)—is obviously associated with the reduction in housebuilding, but not proportionately. One would guess that economy (partly enforced) in the use of timber has led to a considerable increase in the relative net output per standard, but since softwood is only one of many materials used in building, it is impossible to find a suitable net output weight for it. The best solution seemed to be to omit it.

4.3. So crude an index can hardly be regarded as very satisfactory in its own right. But it serves to illustrate further the importance of changes in the input/output ratio. In Table 10 the combined input index is compared with various linked indexes of industrial production in the United Kingdom over the whole period 1851–1856. Up to 1907, Hoffman's well-known index is used (10), and agrees closely in its measurement of the increase from 1851–1856 to 1907–13 with the combined input index—both indexes rising from about 30 to 100. No increase in the productivity of input is apparent over the whole period. This is not particularly surprising, because Hoffman, although using estimated net output weights, relies for his physical output indicators very largely on series which are really input series (output of pig iron, etc.). From 1907 onwards, however, the input index is compared with indexes of production based on detailed statistics of finished output derived from censuses of production, and revised in accordance with the changed composition of industry revealed by the successive censuses. As one would expect from the discussion in Part 3 of this paper, the output index runs far ahead of the input index. In part this is no doubt explained by the much wider industrial coverage of the output index, but a major factor in the difference is, surely, the increase in the net output per unit of input.

4.4. We can choose what moral to draw from this comparison. It may be that productivity per unit of input began to increase only in 1907—just when, by a happy coincidence, statistics to record the increase began to be collected. Or it might be maintained, nothing so metaphysical as the change in the volume of net output can ever be successfully measured; the grosser concept of the tonnage of input is the most accurate measure of productive activity that is likely to be achieved. The less extreme conclusion is the obvious one that indexes of production with a large input element are likely to contain a significant downward bias over long periods, and should be treated with caution.

4.5. Without a more comprehensive index of input, covering all raw material inputs into manufacturing industry, it is impossible to treat the ratio of the output index to the combined input index in Table 10 as anything like an accurate measure of the rise in productivity of input. But the increases in productivity of raw material input exhibited in Part 3 of this paper, especially for metals, suggest that for long period comparison of the volume of net output more attention should be paid to the effects of changes in input/output relationships. The technical solution is that an index of output volume should measure "changes in net output at constant price *margins* per unit". This is the ideal recommended by the United Nations Statistical Office (19) which proposes the formula put forward by Dr. Geary, who called attention to the problem (9). But the necessary calculations cannot be made comprehensively without very full data of input quantities and prices.

4.6. The interest in the series of raw material inputs lies less in the combined index than in the differences between the rates of increase in the main branches of industry. The striking divergence of trend between the metal-using industries and the textile industries, from 1907–13 onwards, has already been exhibited in Diagram 1. Table 11 shows in more detail the rates of growth of the two groups over the whole period. In every period but four the metal-using group was gaining ground significantly over the textile group. The exceptions are: the 1880's, when metal consumption was somewhat reduced (the fall in consumption of iron products was particularly marked in these years, and was not offset by the rise in steel usage); 1907–13, when both cotton and wool consumption enjoyed a sudden spurt—largely due to expanding exports; and the two post-war periods when the immediate post-war decline was more violent in the war-inflated metal-

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TABLE 10

Indexes of Raw Material Consumption and Industrial Production

1907–13 = 100

	Combined Indexes of Raw Material Consumption(1)	*Index of Industrial Production*(2)
1851–56	29	31
1857–63	35	37
1864–70	46	44
1871–77	62	56
1878–82	63	60
1883–90	69	69
1891–96	79	75
1897–1901	94	85
1902–06	97	90
1907–13	100	100
1914–18	98	107
1919–23	95	107
1924–28	111	122
1929–32	105	127
1933–36	127	151
1937–39	133	179
1940–44	135	..
1945–47	118	173
1948–50	149	222

(1) Based on Tables 1 and 2, with the following weights (roughly proportional to the relative net outputs per ton consumed):

Metals	1 per '000 tons.
Textiles	5 through 1914–18, 7 thereafter, per '000 tons.
Softwood	4 per '000 standards.
Rubber	10 through 1924–28, 6 thereafter, per '000 tons.

Softwood is excluded from the combined index after 1937–39 (see para. 4.2).

(2) 1851–1907 and 1914–19, Walter Hoffman's index of production (reference 10). 1907–1924 (except 1914–19), combination of (a) Tolles and Douglas comparisons of 1907 and 1924 Censuses of Production (reference 18) with (b) Rowe's index 1907–24 (reference 15), and (c) Board of Trade and London and Cambridge Economic Service indexes 1920–35 (reference 11), adjusted for comparability by Mr. T. M. Ridley. 1935–1946, Central Statistical Office estimates (Reference 7). 1948–50, Central Statistical Office interim index of industrial production.

TABLE 11

Average Annual Percentage Increase or Decrease of Raw Material Consumption over Preceding Period

	Metals	*Textiles*	*Combined Raw Materials*
1857–63	3·9	1·6	2·6
1864–70	3·9	2·2	4·4
1871–77	4·5	4·8	4·9
1878–82	0	1·0	0·4
1883–90	−0·3	1·7	1·4
1891–96	2·4	1·0	2·1
1897–1901	4·2	0·5	3·4
1902–06	1·7	0·7	0·7
1907–13	0·3	2·0	0·5
1914–18	4·5	−0·7	−0·4
1919–23	−5·1	−4·0	−0·6
1924–28	6·5	0·5	3·5
1929–32	−0·8	−2·4	−1·2
1933–36	3·9	2·7	5·2
1937–39	8·5	0·9	1·5
1940–44	5·4	−6·6	0·4
1945–47	−4·2	−2·6	−3·2
1948–50	7·3	1·3	8·6

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using industries than in textiles. Apart from these interludes, the economy has been shifting continuously from textiles to metals.

4.7. Clark has shown (14) how the rate of increase in productivity practically disappeared in the early part of the 20th century; this is rather faintly reflected in diminishing rates of increase in real output. Table 11 shows how this slackening rate of expansion had been felt in the textile industries since about 1875. In the metal-using industries fluctuations in the rate of expansion were more marked, but there were definite indications, in the fifteen years before World War I, that the long-term upward trend was approaching a plateau.

4.8. The renewal of the forces of expansion in the economy after World War I, in the late 1920's and in the recovery from the 1929–31 depression, were confined to the metal-using group, in which the rates of increase exceeded those of the mid-19th century. There is every indication that the same forces are in operation now.

Home and Export Uses of Metals

4.9. How far has the expansion of the metal-using industries been based on home demand, how far on the expansion of exports? Further research based on the trend of exports of engineering products might contribute to an answer to this question over the whole of the period studied here. Table 12 gives some indication of the answer (based on estimates of steel usage) in respect of the past 25 years only. From this it becomes clear that this second wave of economic expansion —from after World War I to the present time—is due predominantly to the growth of home demand for metal goods. Exports have played a very large part in the past 15 years. But over the period 1924–50 as a whole, while exports of metal products* have grown from an amount roughly estimated at less than 1 million tons (of ingot steel content) 25 years ago to about 3½ million tons in 1950, home consumption has risen from round about 6 million tons to over 11 million tons. Of the more important specific home uses, building perhaps accounts for an increase of 1 million tons out of the total increase of about 5½ million tons, home consumption of motor vehicles and cycles for an increase of much less than 1 million tons, while shipbuilding for U.K. owners is probably slightly less than in 1924. Some part of the increase—certainly not more than 1 million tons—represents consumer goods (other than vehicles). But the bulk of the expansion consists of increased supplies of plant and machinery for British industry, and is one indication of the growth in the rate of real investment of this kind.

TABLE 12

Usage of Finished Steel

Million ingot tons

	1924	1935	1937	1947	1949	1950
Total consumption	6·5	8·5	11·6	12·6	14·3	14·7
Usage						
Exports of metal products	0·8	1·0	1·1	2·0	3·2	3·5
Home consumption of home-produced metal products	5·7	7·5	10·5	10·6	11·1	11·2
of which—building (inc. constructional engineering)	0·9	1·9	2·4	..	1·8	..
Other	4·8	5·6	8·1	..	9·3	..
% exports to consumption	12·3	11·3	9·8	15·7	22·1	24

Sources for estimates of exports of metal products and building usage: 1924, Based on Committee on Industry and Trade: *Survey of Metal Industries*, page 49. 1935–49, British Iron and Steel Federation: Monthly Statistical Bulletins, May, 1948, and July, 1950.

Textiles—Home Market and Export Trends

4.10. More research would be needed to produce a similar analysis of the trend in textiles. But very rough calculations show at once one dissimilarity from the experience of the metal-using industries. The textile industries, and especially the cotton industry, owe their expansion up to

* I.e., excluding exports of steel itself.

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World War I—unlike the metal-using industries—to the development of export markets. By 1907 nearly 90 per cent. of the output in yardage of cotton piece goods was exported (but a significantly smaller proportion in weight or value), approaching half the wool textiles and more than half the jute, linen and silk manufactures. The proportion of textile exports to output, in weight, was probably nearly two-thirds. But since World War I, in contrast with the metal-using industries, the trend of textile export volume, with interruptions, has been downwards; by 1924 exports in weight were probably not much over half as great as in 1907, and in the last three or four years probably not much over a quarter of their level in 1907. And whereas the steady upward trend in home demand for metal products has been since World War I the main stimulus to the development of their output, in textiles the expansion of the home market has been far too small to offset the loss of exports. It is doubtful whether home consumption of textiles, in weight, has increased very much more than 50 per cent. since 1907, although the population has increased by one quarter.

5. *The Trend Away from Self-sufficiency*

5.1. Almost all the expansion in industrial output described here has been fed from imports. Even steel and rayon development have depended chiefly on imported iron ore and woodpulp. in this section the process of diminishing self-sufficiency is examined in detail for the non-ferrous metals, wool and flax.

5.2. For the non-ferrous metals, the distinction must be made between self-sufficiency at the stage of mining the ore, and self-sufficiency in the primary process of smelting. The re-use of secondary material—scrap metals and, in the case of wool, recovered wool or shoddy—can also be regarded as a method of using "home resources". In Table 13 the mining and smelting of the non-ferrous metals, and the use of secondary metal, are set out for selected periods over the century (excluding, however, the early 1850's, for which some of the figures are missing), and compared with total consumption of the finished metal. In Table 14 the analogous comparison is made for wool and flax.

5.3. It will be seen that in only two cases has home production maintained anywhere near its *proportion* of consumption—namely flax, where total consumption has been reduced over the period by nearly two-thirds, and tin smelting. In every case except zinc smelting, tin smelting and aluminium production, there has been a continuous decline in the *absolute* amount of home production.

5.4. Copper mining and smelting, lead mining and smelting and tin mining had all fallen to negligible amounts by the 1920's, the decline in mining preceding the decline of smelting. Indeed copper mining practically vanished in the 1860's, when the high-grade Anglesey deposits were worked out. Britain's long predominance as the world's chief producer of all these metals came to an end soon after the middle of the 19th century.

5.5. The significant recent developments of the use of home resources among the non-ferrous metals are:

(*a*) the expansion of zinc mining just before and during World War II, which has not, however, been maintained;

(*b*) the enlargement of the zinc smelting industry in World War I, founded on a contract made by the British Government with the Australian mines in 1916, to take specific quantities of concentrates for as long as 15 years. Smelting output expanded gradually through the inter-war period but the smelters do not appear to have been working to full capacity until World War II. Since the war output has been maintained;

(*c*) the enlargement of the tin smelting industry, also during World War I. The United Kingdom has indeed been a net exporter of tin metal since before World War I, and although substantial amounts of tin metal were imported from the 1880's until 1931 (partly for re-export), the United Kingdom has never been a net importer of metal on any considerable scale;

(*d*) the development of aluminium production, especially after World War I, with the Lochaber scheme.

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5.6. Much more important a way of using home resources is the immense development during World War II of the use of secondary metal, which now accounts for approximately half the total consumption of copper and lead, and about one-third of the zinc and aluminium.

5.7. Home wool production was fairly stable up to World War I, but has been declining steadily since. The use of shoddy (the estimates of course being very rough for most of the period) was apparently rising, both absolutely and in proportion to total wool consumption, until just before

TABLE 13

Home Production Compared with Total Consumption—Non-Ferrous Metals

'000 *tons*

	Home Consumption	*Of which—* *Smelted in U.K. from U.K. Ore*	*Total Smelted in U.K.*	*From Scrap*
Copper				
1857–63	21	15	42	—
1883–90	30	2	63	—
1907–13	82	1	52	—
1914–18	185	0·2	43	—
1924–28	131	0·1	20	—
1937–39	331	0·1	7	(50)
1940–44	689	—	4	(240)
1948–50	397	—	—	183
Zinc				
1857–63	20	3	3	—
1883–90	85	10	23	—
1907–13	155	6	35	—
1914–18	137	4	51	—
1924–28	177	1	39	—
1937–39	220	6	56	—
1940–44	352	10	67	(113)
1948–50	281	—	69	88
Lead				
1857–63	62	67	67	—
1883–90	134	38	58	—
1907–13	188	20	34	—
1914–18	186	14	22	—
1924–28	252	(3)*	6	—
1937–39	351	11*	11	—
1940–44	305	7	7	(65)
1948–50	329	2	2	163
Aluminium				
1924–28	17	—	9	—
1937–39	56	—	22	—
1940–44	226	—	36	61
1948–50	197	—	30	76
Tin				
1857–63	8	7	7	—
1883–90	17	9	10	—
1907–13	24	5	21	—
1914–18	25	5	29	—
1924–28	23	2	42	—
1937–39	26	(2)	37	—
1940–44	30	1	36	(7)
1948–50	30	1	29	(8)

* Substantial exports of ore in addition.

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TABLE 14

Home Production Compared with Total Consumption—Wool and Flax

	Home Consumption	*Of which—*	
		U.K. Production (inc. export)	*Secondary material*
Wool—incl. hair as recovered wool (million lb. actual weight)			(Recovered wool)
1857–63	289	(143)	(41)
1883–90	534	134	107
1907–13	827	135	205
1914–18	877	121	166
1924–28	636	114	73
1937–39	829	111	(90)
1940–44	549	103	(75)
1948–50	822	79	60
Flax ('000 tons)*			
1857–63	115	51	..
1883–90	85	19	..
1907–13	81	10	..
1914–18	72	15	..
1924–28	37	6	..
1937–39	44	4	..
1940–44	33	19	..
1948–50	39	(12)	..

* The production figures before 1924 are estimates based on acreage.

World War I, when it reached one quarter of total consumption. The proportion fell after the war to not much above a tenth of total consumption, and in absolute quantities has never again exceeded half the 1907–13 amount. The proportion in 1948–50 was as low as it has ever been (7 per cent.) and the actual amount used less than any time since the 1860's (in spite of some expansion at the end of 1950 when wool prices rose violently—an expansion which has continued since but has still not reached pre-war levels).

5.8. The decline in flax output was interrupted only by the two wars, when special efforts were made to develop it. In World War II it reached levels probably not seen since the early 1880's, and has, moreover, since been maintained not at war-time levels, but at levels higher than at any time since World War I. (The figures in the table do not allow for the separation of the Irish Republic from the United Kingdom.)

5.9. Timber has not been analysed in the same way, since detailed statistics of home production do not exist for most of the period. So far as can be seen, home production has not supplied more than about 5 per cent. of total softwood supplies (excluding sleepers) except in war-time. In World War I the proportion may for a time have exceeded half a somewhat reduced level of consumption. In World War II, however, the expansion of home supplies was never large enough to account for as much as half of a total consumption much more drastically reduced than in the first war.

Acknowledgment

I must acknowledge considerable help from my wife, and from Mrs. E. J. Donovan, Miss D. E. Ramsay and Mr. E. A. Woodroof in compiling the statistics.

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APPENDIX

1. *Notes on the Statistics*

These notes supplement the general description of the statistics in Part 2 of the paper.

General

For the meaning of "consumption" see paragraphs 2.1 to 2.7.

Sources.—Generally, the statistics of *imports:*, *re-exports* and *exports* used in the compilation of the estimates of consumption are taken from the *Statistical Abstracts of the United Kingdom* for the years 1851 to 1912, from the *Annual Statements of Trade* for the years 1913 to 1948, and from the monthly *Trade and Navigation Accounts* for the years 1949 and 1950. After 1912, therefore, there are minor breaks in continuity in so far as the foreign trade statistics used are thereafter more comprehensive. There are no doubt other breaks in continuity due to changes in classification in the trade accounts and to improving accuracy of classification.

The statistics of *stock changes* used in the estimates of consumption are generally those given in the *Abstracts of Statistics* (Nos. 84 to 88). Most of these series begin only about 1941.

Steel.—The consumption figures represent finished steel, expressed in finished weight.

1851–1899

Production: 1851–1881 from Statistical Tables relating to British and Foreign Trade and Industry 1909. Cmd. 4954. (1856–64 estimated by interpolation.)

Production: 1882–1899 from British Iron and Steel Federation: Statistics of the Iron and Steel Industry of the United Kingdom 1938.

Imports and Exports: from statistical abstracts. The division between "iron" and "steel" is partly arbitrary (see paragraph 2.12).

1900–1924

Consumption, Production, Imports and Exports: from Shone, R. M. "The iron and steel development plan: some statistical considerations", *J. Royl Statist. Soc.*, **110**, Part IV 1947, p. 284. The figures are in ingot equivalents and are converted to finished weight by subtraction of 25 per cent.

1925–50

Consumption, Production, Imports and Exports: from British Iron and Steel Federation. Statistics of the Iron and Steel Industry, Part I: U.K. 1950

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Iron Products.—See paragraphs 2.13 and 2.14.

(a) *Pig-iron production:* throughout from British Iron and Steel Federation: statistics of the Iron and Steel Industry, Part I, U.K. 1938 and 1950. Ferro-alloys are excluded (estimates made of production of ferro-alloys before 1893 by interpolation, assuming production negligible before 1881).

(b) *Pig-iron imports and exports:* from Statistical Abstracts to 1912 and Annual Statements of Trade thereafter (also excluding ferro-alloys).

(c) *Pig-iron used in steel-making:* 1851–1919 (see paragraph 2.13). The method is based on steel production by process, as stated in B.I.S.F. Statistics of the Iron and Steel Industry, Part I, U.K., 1938 and 1950.

1920–1950—*B.I.S.F. Statistics of the Iron and Steel Industry.* Part I: U.K., 1938 and 1950.

(d) Pig-iron content of Production of iron products: derived from (a) + (b) − (c).

(e) Imports and exports of iron products: see paragraph 2.12.

Non-ferrous Metals (copper, zinc, lead, aluminium, tin).

Imports and exports from Statistical Abstracts to 1912. Thereafter from Annual Statements of Trade and Monthly Trade Accounts. So far as possible the items of imports and exports included are those now shown in Class III D, brass being assumed to consist of two-thirds copper, one-third zinc. In earlier years, there were considerable imports and exports recorded as "Unenumerated metals" which have been ignored. Imports and exports taken into account before calculating U.K. consumption are mainly semi-manufactures (bars, rods, plates, sheets, etc.); they include, however, certain finished goods, such as hollow-ware, which cannot be separately distinguished throughout the period; they also include uninsulated wire. Electric cable, copper sulphate and lead and zinc oxides are not taken into account; i.e., exports are treated as part of the consumption of the metal-using industries, and imports are not included in that consumption.

Smelter production

To 1912

Copper: From Annual Reports on Mines and Quarries: Home Office (later Mines Department). This series shows in the case of copper, metal obtainable from imported ores as well as from U.K. mining.

Zinc: From U.K. mined-ore: as for copper. From imported ore: from net imports of ore and concentrates, assuming metal content 50 per cent.

Lead: From U.K. mined ore: as for copper. From imported ore: as for copper after 1881; 1851–1880 estimated from net imports of ore.

Tin: From U.K. mining: as for copper. From imported ores and concentrates: from net imports of ores and concentrates.

1913–1939 from Statistical Summary of the Mineral Industry. Minerals Resources Division of the Colonial Office (before 1945 of Imperial Institute).

1940–1950 from Statistical Abstracts of the U.K.

Stock changes (from 1941 only, except aluminium from 1938) from Statistical Abstracts of the U.K. (based on the statistics of stocks of primary metal now compiled by the Non-Ferrous Metals Bureau).

Secondary metal consumption (see paragraph 2.18) (from 1942 only, except aluminium from 1940) from Statistical Abstract of the U.K.

Cotton

Consumption

1854–1908 from Statistical Tables relating to British and Foreign Trade and Industry 1909, Cmd. 4954 ("Fiscal Blue Book"). Represents deliveries to mills.

1909–1939 from International Federation of Master Cotton Spinners' and Manufacturers' Associations: International Cotton Bulletins. Converted from bales to tons on average bale weights supplied by Cotton Board (1909–22 figures are averages of crop years ending July 31). Figures are actual mill consumption.

1939–50, Statistical Abstract of the U.K. Figures are actual mill consumption (based on returns compiled by the Cotton Control and Raw Cotton Commission).

Wool (see para. 2.20)

Imports, re-exports and exports. 1851–1912 from Statistical Abstracts. 1913–50 from Annual Statements of Trade and Monthly Trade Accounts. Includes sheeps' and lambs' wool, alpaca, vicuna and llama wool; camels' hair (from 1900 only) and mohair.

Estimated wool supplies from imported woolled sheepskins: the original sources are the annual "Statistics relating to the worsted, woollen and artificial silk trades of the U.K." published by Bradford Chamber of Commerce, from 1851 to 1932. (Up to 1908, the figures are given in the "Fiscal Blue Book" 1909). For 1933–50, 70 per cent. of the retained imports of woolled sheepskins, as recorded in the Annual Statements of Trade, etc., has been used, to provide continuity with the Bradford series; somewhat different figures (with different assumptions about the proportion of

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woolled sheepskins going to the wool industry) are given by the Commonwealth Economic Committee in their publications.

Home production of wool: 1851–1908. From "Fiscal Blue Book" 1909 (based on Bradford series). 1909–1950 from Statistical Abstracts.

Estimated supplies of recovered wool. 1851–1932. From Bradford series (as quoted in Fiscal Blue Book to 1908). 1933–1939 from Commonwealth Economic Committee (World Consumption of Wool, 1949). 1940–42, interpolated. 1943–45 from Wool Industry Bureau of Statistics. 1946–50 from Statistical Abstracts (based on statistics compiled by Wool Industry Bureau of Statistics).

Consumption (exc. recovered wool) 1940–50. Figures derived from production, imports and exports adjusted for stock changes by reference to records of actual consumption in clean weight, collected by Wool Control and Wool Industry Bureau of Statistics and published in Statistical Abstracts.

Rayon

Production of continuous filament, staple fibre, and other synthetic textiles:
1922–1925. Committee on Industry and Trade ("Balfour Report"). Survey of the Textile Industries pp. 285 and 305.
1926–1934. Quantities charged with duty as stated in Statistical Abstracts.
1935–1950. Statistical Abstracts.

Imports, re-exports and exports: from Annual Statements of Trade and Monthly Trade Accounts. The figures include artificial silk waste, yarn thread and filament (including mixtures so far as specified).

Silk (raw); *jute; hemp* dressed and undressed plus "other like substances" (including coir and ramie); *flax*, dressed and undressed: *imports, re-exports and exports* from Statistical Abstracts to 1912 and thereafter from Annual Statements of Trade and Monthly Trade Accounts (exports of flax and hemp are combined and treated as flax).

Home production of flax (in terms of scutched flax): 1909–13 average from Statistical Tables relating to British and Foreign Trade and Industry (1924–30) Part II, p. 270 (Cmd. 2849, 1931). 1924–38 from Statistical Abstract. 1938–49 from Commonwealth Economic Committee "Industrial Fibres" 1951. For all other years back to 1866, the production figures are estimated from acreages as shown in Statistical Abstracts, assuming output as one-sixth of a ton per acre, which appears to be the average yield in 1909–13 and from 1924 to 1945. Before 1866 the figures are unsupported guesses, assuming that the downward trend from 1866–1900 was already in progress in 1851–1865 though at a more moderate rate than after 1865.

Softwood (see paras. 2.22–24)

Imports

1851–1912. From Statistical Abstracts.
1913–50. From Annual Statements of Trade and Monthly Trade Accounts.

The classification varies somewhat over the period; so far as possible the series used here covers items now described as—

Softwood, sawn, not further prepared.
,, planed or dressed, inc. boxboard.
,, hewn (exc. pitwood).
,, sleepers.

The important breaks in the continuity of the series are:

(*a*) To represent "softwood", I have had to take from 1851 to 1889 all timber other than teak and mahogany; and for 1890 to 1918, "Fir". (*b*) Hewn timber is introduced only from 1901; previously, pitwood—which appears to have accounted for most of the hewn imports—was not separately stated.

Home Production, see paragraph 2.23.

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2. *Annual Estimates of Raw Material Consumption*

(a) *Metals*

'000 *long tons*

	(1) *Steel*	(2) *Iron products*	(3) *Copper*	(4) *Zinc*	(5) *Lead*	(6) *Aluminium*	(7) *Tin*
1851	—	1,200	16	20	61	—	7
1852	—	1,700	17	13	58	—	6
1853	—	1,800	19	14	63	—	5
1854	—	2,000	22	14	56	—	5
1855	—	2,200	30	15	51	—	7
1856	—	2,200	27	15	60	—	7
6 year average	—	1,850	22	15	58	—	6
1857	30	2,100	23	16	60	—	8
1858	30	2,100	19	19	62	—	8
1859	30	2,300	24	20	66	—	7
1860	75	2,400	24	18	61	—	7
1861	75	2,400	30	19	70	—	7
1862	75	2,400	22	16	57	—	7
1863	75	2,800	4	30	61	—	9
7 year average	55	2,350	21	20	62	—	8
1864	75	3,200	17	27	62	—	11
1865	150	3,100	26	29	75	—	10
1866	150	2,700	24	30	74	—	11
1867	150	2,700	7	30	84	—	9
1868	225	2,800	13	42	76	—	10
1869	225	2,700	19	42	74	—	10
1870	225	3,100	9	45	96	—	12
7 year average	170	2,900	16	35	77	—	10
1871	300	3,400	4	40	110	—	13
1872	375	3,100	27	42	99	—	11
1873	450	3,200	9	46	96	—	15
1874	450	3,100	9	43	98	—	12
1875	525	3,700	20	50	113	—	18
1876	675	4,100	27	54	116	—	14
1877	600	4,200	48	59	126	—	14
7 year average	480	3,550	21	48	108	—	14
1878	750	3,500	49	57	139	—	15
1879	675	2,700	40	59	135	—	12
1880	825	3,500	23	66	132	—	15
1881	750	3,600	13	83	112	—	15
1882	900	3,300	25	80	113	—	16
5 year average	780	3,300	30	69	126	—	15
1883	825	3,600	24	85	122	—	17
1884	675	3,500	27	83	139	—	17
1885	750	3,200	40	87	128	—	18
1886	825	2,700	29	75	140	—	15
1887	1,050	2,200	14	81	126	—	19
1888	1,350	2,700	45	91	139	—	13
1889	1,350	2,700	34	87	143	—	18
1890	1,350	2,300	25	88	137	—	19
8 year average	1,020	2,850	30	85	134	—	17

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(a) *Metals* (continued)

'000 *long tons*

	(1) *Steel*	(2) *Iron products*	(3) *Copper*	(4) *Zinc*	(5) *Lead*	(6) *Aluminium*	(7) *Tin*
1891	1,200	2,900	41	96	154	—	18
1892	1,275	2,700	28	86	154	—	18
1893	1,125	3,000	38	89	158	—	19
1894	1,425	3,400	56	91	143	—	22
1895	1,425	3,600	37	96	157	—	26
1896	1,650	3,600	62	103	181	—	22
6 year average	1,350	3,200	44	94	158	—	21
1897	1,950	3,200	64	99	173	—	15
1898	2,325	3,200	62	119	200	—	8
1899	2,475	3,500	51	106	189	—	13
1900	2,790	2,900	81	103	187	—	15
1901	2,770	2,800	62	96	211	—	22
5 year average	2,460	3,100	64	105	192	—	15
1902	2,455	3,200	73	121	228	—	18
1903	2,545	3,200	52	119	217	—	18
1904	2,610	3,300	80	131	218	—	18
1905	2,950	3,700	50	131	199	—	17
1906	3,255	2,800	65	134	178	—	21
5 year average	2,760	3,250	64	127	208	—	18
1907	2,920	2,400	66	134	181	—	24
1908	2,485	3,200	100	128	218	—	25
1909	2,640	3,300	113	148	188	—	20
1910	2,965	3,400	54	171	195	—	23
1911	3,360	2,900	71	157	184	—	23
1912	3,615	2,100	78	174	178	—	21
1913	4,500	3,000	92	173	172	—	29
7 year average	3,210	2,900	82	155	188	—	24
1914	4,410	1,900	155	165	213	—	22
1915	4,980	2,200	222	150	215	—	37
1916	5,190	2,200	141	123	145	—	26
1917	6,195	2,500	173	128	142	—	22
1918	6,385	2,900	232	117	215	—	19
5 year average	5,430	2,350	185	137	186	—	25
1919	4,590	2,600	91	119	194	(2)	24
1920	5,110	2,100	68	99	116	2	25
1921	2,605	1,600	54	63	108	3	9
1922	2,460	1,700	31	93	152	5	19
1923	4,015	2,600	86	158	187	9	15
5 year average	3,755	2,100	66	106	151	4	18
1924	4,890	3,000	122	156	218	14	23
1925	4,960	2,300	145	173	256	16	19
1926	3,345	1,400	113	169	259	16	19
1927	7,135	3,300	127	190	281	20	23
1928	5,580	2,300	147	198	244	19	31
5 year average	5,180	2,450	131	177	252	17	23
1929	6,285	2,500	153	209	274	28	26
1930	5,425	2,900	160	200	299	30	25
1931	4,600	1,900	158	180	305	30	27
1932	3,795	1,700	150	122	251	13	15
4 year average	5,025	2,250	155	178	282	25	23

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(a) Metals—(*continued*)

'000 *long tons*

	(1) *Steel*	(2) *Iron products*	(3) *Copper*	(4) *Zinc*	(5) *Lead*	(6) *Aluminium*	(7) *Tin*
1933	4,645	1,500	(157)	137	276	19	−11
1934	6,070	2,300	(263)	186	309	24	14
1935	6,415	2,100	(283)	204	307	28	12
1936	8,070	2,600	(244)	237	338	38	22
4 year average	6,300	2,100	237	191	308	27	9
1937	8,715	3,000	(327)	235	336	45	25
1938	6,930	2,500	(298)	215	381	43	30
1939	9,610	1,900	(369)	211	337	81	22
3 year average	8,415	2,450	(331)	220	351	56	26
1940	10,455	2,500	(614)	(320)	(364)	146	(27)
1941	10,530	2,500	(594)	(362)	(273)	161	(36)
1942	11,085	2,100	820	393	326	267	33
1943	10,860	2,200	805	376	276	330	29
1944	10,044	2,000	613	308	285	226	27
5 year average	10,595	2,250	(689)	(352)	(305)	226	(30)
1945	8,136	1,900	449	250	299	139	28
1946	8,101	2,600	367	252	317	173	29
1947	8,909	2,900	450	298	323	229	32
3 year average	8,382	2,450	422	267	313	180	30
1948	9,550	3,300	421	289	332	183	31
1949	10,250	3,300	347	251	324	179	(30)
1950	10,500	3,400	422	303	330	230	(30)
3 year average	10,100	3,350	397	281	329	197	(30)

(b) *Textile Materials, Softwood and Rubber*

	(1) *Cotton*	(2) *Wool*	(3) *Rayon*	(4) *Silk*	(5) *Flax*	(6) *Hemp, etc.*	(7) *Jute*	(8) *Softwood*	(9) *Rubber*
Unit:	'000 *tons*	*mn. lb.*	*mn. lb.*	*mn. lb.*	'000 *cwts.*	'000 *cwts.*	'000 *tons*	*mn. stds.*	'000 *tons*
1851	290	230	—	4·06	1,988	924	18	·3	1
1852	330	239	—	5·13	2,197	693	18	·3	1
1853	335	271	—	6·05	2,674	949	14	·4	2
1854	345	242	—	6·44	2,173	707	24	·4	2
1855	375	228	—	4·43	2,210	710	26	·3	3
1856	400	255	—	5·94	2,520	734	37	·4	2
6 year average	346	244	—	5·34	2,294	786	23	·4	1·8
1857	370	262	—	10·37	2,675	761	31	·4	2
1858	405	275	—	3·97	2,085	817	36	·4	2
1859	435	287	—	7·77	2,163	1,034	52	·4	1
1860	485	302	—	6·03	2,310	718	41	·4	3
1861	450	274	—	4·61	2,130	745	41	·5	3
1862	200	314	—	5·16	2,506	887	42	·5	3
1863	230	309	—	5·37	2,198	938	53	·6	3
7 year average	368	289	—	6·18	2,295	843	42	·5	2·4
1864	250	355	—	1·74	2,511	917	87	·7	4
1865	320	336	—	4·59	2,565	905	84	·7	4
1866	400	380	—	3·48	2,197	844	60	·7	3
1867	425	373	—	3·95	2,142	793	61	·7	3
1868	445	396	—	4·11	2,239	970	88	·8	6
1869	420	383	—	2·52	2,048	949	102	·8	6
1870	480	410	—	3·67	2,667	1,016	98	·9	7
7 year average	391	376	—	3·44	2,338	913	83	·8	4·7

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(b) *Textile Materials, Softwood and Rubber* (continued)

	(1) *Cotton*	(2) *Wool*	(3) *Rayon*	(4) *Silk*	(5) *Flax*	(6) *Hemp, etc.*	(7) *Jute*	(8) *Softwood*	(9) *Rubber*
Unit:	000 *tons*	*mn. lb.*	*mn. lb.*	*mn. lb.*	'000 *cwts.*	'000 *cwts.*	'000 *tons*	*mn. stds.*	'000 *tons*
1871	540	448	—	4·98	2,650	1,142	144	·9	6
1872	525	445	—	4·09	2,107	934	164	·9	7
1873	555	481	—	3·66	2,386	1,105	191	1·0	8
1874	565	485	—	3·17	2,381	1,108	178	1·1	5
1875	550	472	—	1·94	1,795	1,176	118	1·0	5
1876	570	492	—	2·96	1,553	993	144	1·2	5
1877	550	501	—	2·79	2,190	1,034	134	1·4	5
7 year average	551	475	—	3·37	2,152	1,070	153	1·1	5·9
1878	525	477	—	2·33	1,668	1,075	161	1·1	5
1879	525	445	—	2·51	1,874	1,007	182	1·0	6
1880	615	530	—	2·72	2,073	983	178	1·2	8
1881	645	458	—	2·00	1,895	1,126	181	1·1	7
1882	650	503	—	2·46	2,028	1,089	225	1·3	8
5 year average	592	483	—	2·40	1,908	1,056	185	1·1	6·8
1883	670	482	—	2·66	1,572	1,187	276	1·3	10
1884	655	511	—	4·14	1,607	1,061	171	1·2	7
1885	595	493	—	1·70	1,726	1,067	188	1·3	7
1886	655	539	—	1·70	1,416	891	173	1·1	6
1887	665	515	—	2·37	1,737	1,044	221	1·1	7
1888	680	555	—	2·90	1,911	1,158	211	1·3	6
1889	685	597	—	2·73	1,888	1,190	267	1·6	8
1890	740	577	—	1·70	1,768	1,148	260	1·5	9
8 year average	668	534	—	2·49	1,703	1,093	221	1·3	7·5
1891	745	652	—	2·35	1,594	989	235	1·4	9
1892	680	594	—	1·34	1,624	951	169	1·6	8
1893	660	635	—	2·15	1,388	1,070	172	1·5	9
1894	720	656	—	1·33	1,510	1,253	226	1·7	8
1895	730	680	—	1·47	1,973	1,475	274	1·6	10
1896	735	690	—	1·56	1,695	1,075	240	1·9	11
6 year average	712	651	—	1·70	1,631	1,136	219	1·6	9·2
1897	725	654	—	1·72	1,657	1,190	237	2·2	10
1898	775	725	—	2·03	1,684	1,251	246	2·0	12
1899	785	677	—	2·14	1,661	967	188	2·0	11
1900	725	655	—	1·22	1,254	1,324	173	2·0	16
1901	735	704	—	1·09	1,240	1,363	199	2·1	12
5 year average	749	683	—	1·64	1,499	1,219	209	2·1	12·2
1902	730	667	—	1·10	1,207	1,350	392	2·2	10
1903	695	626	—	0·93	1,610	1,385	159	2·2	9
1904	700	644	—	1·15	1,275	1,683	203	2·0	11
1905	830	682	—	0·97	1,593	1,466	227	2·0	14
1906	850	734	—	0·95	1,447	1,387	231	2·2	15
5 year average	761	671	—	1·02	1,426	1,454	242	2·1	11·8
1907	880	833	—	1·12	1,804	1,621	226	2·0	17
1908	770	741	—	1·07	1,645	1,546	249	1·9	12
1909	783	(765)	—	1·00	1,552	1,543	200	1·9	16
1910	796	872	2	0·96	1,471	1,679	202	2·0	21
1911	900	876	2	0·86	1,348	1,814	191	1·9	20
1912	970	833	3	1·07	1,776	1,906	245	1·9	21
1913	966	872	4	0·93	1,729	1,829	221	2·2	30
7 year average	866	827	(2)	1·00	1,618	1,705	219	2·0	19·6

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(b) *Textile Materials, Softwood and Rubber*—continued

	(1) *Cotton*	(2) *Wool*	(3) *Rayon*	(4) *Silk*	(5) *Flax*	(6) *Hemp, etc.*	(7) *Jute*	(8) *Softwood*	(9) *Rubber*
Unit:	'000 *tons*	*mn. lb.*	*mn. lb.*	*mn. lb.*	'000 *cwts.*	'000 *cwts.*	'000 *tons*	*mn. stds.*	'000 *tons*
1914	916	759	4	1·01	1,484	1,555	158	1·6	21
1915	885	1,160	3	1·31	1,333	1,985	295	1·7	20
1916	849	951	3	1·15	1,673	2,139	160	1·4	32
1917	736	879	4	1·27	1,688	1,777	82	1·1	28
1918	657	637	3	1·90	980	2,060	203	1·5	35
5 year average	809	877	3	1·33	1,432	1,903	180	1·5	27
1919	711	1,226	5	1·16	520	1,560	204	2·0	49
1920	622	898	(9)	·95	720	2,060	180	1·8	65
1921	554	594	11	·38	420	760	84	·9	45
1922	629	823	16	·97	660	1,120	141	1·5	15
1923	606	498	18	·69	540	1,420	127	1·8	17
5 year average	624	808	12	0·83	572	1,384	147	1·6	38
1924	667	638	28	·76	740	1,700	170	2·0	–5
1925	749	594	30	·76	620	1,460	185	2·0	12
1926	634	657	22	·98	860	1,180	115	1·9	91
1927	700	661	35	1·16	860	1,700	234	2·3	65
1928	638	632	43	1·49	640	1,560	194	1·8	9
5 year average	678	636	32	1·03	744	1,520	180	2·0	34
1929	621	685	48	1·39	820	1,580	202	2·1	129
1930	446	720	40	1·33	720	1,500	127	2·1	126
1931	483	804	47	1·87	600	1,540	139	1·8	90
1932	506	815	58	2·32	620	1,320	129	1·7	46
4 year average	514	756	48	1·73	690	1,485	149	1·9	98
1933	550	821	70	2·79	580	1,500	158	2·2	75
1934	543	733	75	3·52	780	1,860	173	2·5	160
1935	572	772	103	5·19	760	1,900	152	2·2	102
1936	608	835	123	5·27	940	2,020	166	3·4	107
4 year average	568	790	93	4·19	765	1,820	162	2·6	111
1937	624	762	123	5·83	820	2,260	170	2·7	125
1938	483	806	108	5·49	860	1,860	160	2·1	116
1939	574	(918)	127	(5·00)	980	2,400	142	1·7	133
3 year average	560	829	119	5·44	887	2,173	157	2·2	125
1940	603	775	137	(3·50)	(800)	(2,500)	150	·92	157
1941	412	590	97	1·98	700	2,100	112	1·06	165
1942	378	530	99	1·63	420	2,080	101	·77	131
1943	367	435	105	·39	660	1,860	82	·68	157
1944	346	415	113	·34	680	1,660	75	·85	147
5 year average	421	549	110	1·57	652	2,040	104	0·86	151
1945	308	440	109	·33	600	1,760	72	·88	140
1946	344	595	136	·80	680	1,620	88	1·12	210
1947	343	685	172	1·31	680	1,880	95	1·05	244
3 year average	332	573	139	0·81	653	1,753	85	1·02	198
1948	417	800	203	1·27	840	1,920	100	1·18	259
1949	424	810	258	1·66	720	2,040	88	1·26	214
1950	442	855	318	1·63	800	2,180	105	1·15	252
3 year average	428	822	260	1·52	787	2,047	98	1·20	242

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Discussion on Mr. Saunders's Paper

Mr. Shone: In proposing this vote of thanks I should like to congratulate Mr. Saunders on a most interesting paper. It is certainly a most important contribution to the discussion of problems now affecting the country with which many of us are intimately concerned.

I will discuss some of the broad conclusions which seem to emerge. The most striking is summarized in the diagram reproduced on page 322, which contrasts the expansion in the metal industries with the more recent downward trend in the textile industries. The increase in output of the metal-using industries is given as 90 per cent. in 1935–1950. This is a very big increase. I have to talk mainly in terms of steel, because Mr. Saunders's particular method of measuring input of materials gives greater weight to the heavier materials in steel and iron. The increase reflects the greatly increased consumption of iron and steel. High consumption during the war period was made possible by lease-lend steel from America. In the post-war period there was a drop; consumption went up again in 1950, and is now substantially higher again, which explains the present shortage of materials. There is a particular shortage of steel because there was no development work in the five war years, and schemes are only now beginning to materialize.

Table 12 gives an interesting explanation of the main elements in the increased consumption of steel since before the war. It brings out clearly the big increase in the consumption of metals for engineering exports from 1·1 m. tons in 1937 to 3·5 m. tons (three times as much) in 1950. In terms of value the increase in engineering exports is from about £100 million in 1937 to over £1,000 million in 1951—an important expansion from the point of view of the balance of payments. It is much more striking than the increase in home consumption of steel, which is only from 10·5 to 11·2 million tons, showing that the general scale of the investment programme is not much above the pre-war level.

The country is relying on a further expansion in metal goods exports this year, so that the figure of 3·5 million tons of steel may go up to 4 million tons. This post-war development involves great risks for the country. It means that our eggs are heavily in the basket of capital goods exports, and subject to all the risks which we know of trade fluctuations. Germany and Japan are coming back into the export market, and American competition must be expected to grow as resources are released from the armament programme. In due course, therefore, if we are to be as dependent on our engineering industries as seems inevitable, we may have to face a problem which will not be a matter of shortages, but one of efficiency and the development of new products.

My second main comment on Mr. Saunders's paper concerns the question of efficiency in the use of metals. This is a particularly important subject now when raw material shortages are our main bottle-neck. It is possible to measure productivity in many ways, the normal way being in terms of labour. The steel industry's productivity team which recently went to America found that, while American output per man was higher than in this country, output per ton of fuel was lower. In other words, we operate our furnaces with optimum fuel efficiency, and they operate theirs to secure optimum labour efficiency.

Mr. Saunders has looked at the question of productivity in terms of materials—a vital matter at the present time. He has found that the increase in productivity of metals was less in the last 15 years (17 per cent.) than in the previous 11 years (22 per cent.). There are a number of reasons, including the trend towards the production of more highly finished articles which require more processing, application of skill and so on. We are importing more food and materials, and switching exports from the minimum processed material to the highest valued products; that trend must continue if we are to get ahead. The figures look as though we have not made quite such rapid progress as might have been expected. This may be due partly to the limitations of supplies in the post-war period. Much of the improvement over the whole period has been in the substitution of the stronger, lighter, steel for cast iron. But this trend has lately been reversed: steel has been strictly allocated and cast iron has been free, and that may have checked the natural growth in the efficient use of ferrous materials.

Another important point is that there has been a substantial substitution, fostered during the war, of steel for timber, especially for pit-props and in the construction of railway carriages and wagons; this would increase the input of metals in relation to the output of finished articles. I do not think Mr. Saunders brings timber in as one of his materials; thus the saving on the timber does not appear in the statistics, which is partly why he finds a big improvement of productivity in terms of metals in the pre-war years and not so much in the post-war period. The change from timber to steel took place during the war and has continued since.

This is a most interesting and admirable paper which many of us will study with the greatest care. It sets out the sort of considerations which are of the highest importance in making estimates

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for future requirements and long-term planning. It is not only of interest from a statistical point of view, but of permanent value to industry.

Mr. GLENDAY: In reading this paper I was reminded of an epigram by Edmund Bishop quoted in a recent economic text-book, to the effect that to write a really great book three men are necessary: a German to collect all possible and impossible material, an Englishman to use his judgment in selecting what is useful and relevant, and lastly a Frenchman with the literary instincts to write it. This is not intended as a criticism of the paper or of the author, but I quote it to illustrate the feeling of bewilderment of someone like myself who tries to bring down the statistics in this paper and the notions in it to the level of the factory and workshop. I have not the advantage of Mr. Shone, who is one of the leading experts not only in the statistical problems of the iron and steel industry, but also on its operative side. My comments are from one who has some knowledge of industry in general but no specialized knowledge of any particular section.

It falls strangely on my ears to find the word "productivity" used in the sense it is used in this paper in referring to the output from raw materials. I wonder whether we could not use some other phrase for this latter, such as "economy" or "efficiency of utilization". The reason I make the suggestion is that as a result of the work of the teams of the Anglo-American Council on Productivity, the word "productivity" have become closely associated in the public mind with output per man hour or per man-year. To use it for another purpose may, I fear, cause unnecessary confusion.

Clearly the paper covers an extremely worth while piece of research which should prove very valuable, though I dare say that Mr. Saunders would agree that its main value lies in indicating bases on which to found further research rather than in offering firm conclusions on the existing data.

I will confine my general observations on the paper to certain statements which appear on p. 313. The paper, we are told, "sets out one way of measuring the growth of manufacturing industry and the changes in its structure"; it is hoped that the "figures may be of some interest in their own right as indicators of the rate of historic expansion"; thirdly, "they provide one kind of scaffolding for economic history". This I found very promising and stimulating until I came with no little shock up against the statement: "the periods of years over which the statistics are averaged are intended to be trade cycles". I was beginning to hope that that descriptive fiction the "trade cycle", forced on economists by the limitations of traditional economic theory, was on the way out as a result of the work of people like Schumpeter, Wesley Mitchell, Alvin Hansen and others. Instead of vainly attempting to bring cycles of varying origin, periodicity and duration under the umbrella of a single simple cycle it is, I submit, more helpful if in the context of such material as that analysed in Mr. Saunders's paper one concentrates on what I may for convenience dub "cycles of development" or "waves of innovation". These are essential features of the process of economic growth.

I may illustrate what I mean by referring to some of the "cycles of development" which occurred in the period covered by Mr. Saunders's statistics, and which seem to have some bearing on the interpretation to be placed upon them. For example, the figures in Table 1 on p. 320 and also those on p. 334, start in the period of rising prices which lasted roughly from 1848 to 1873, when the outstanding element in the impulse to economic expansion was the wave of overseas railway development and shipbuilding. A second, and entirely different type of wave, started in 1873 and lasted until 1896. This was a period of falling prices, during which the areas of expansion secured in the previous wave were consolidated. During this period the railways and ships constructed in the earlier cycle acted as pipelines between the previously inaccessible superfluity of the new countries and the old world eager for more food and raw materials. It was associated with investment of an entirely different *quality* from that in the previous wave. This investment was used to increase the local productivity of labour, raise the standard of living in the old world and develop the new centres of distribution opened up by the railways and ships. That period, which is customarily referred to as the "Great Depression", was from the point of view of Mr. Saunders's paper possibly something quite different. It may be recalled that the famous Dr. Marshall, commenting on the period, said that while he saw a depression in prices, a depression of interest and a depression of profits, he could not "see any reason for believing that there was any considerable depression in any other respect". The truth is that, as to-day, a condition of perpetual booming prices and profits tended to be regarded by the business community of those days as an essential of economic growth and prosperity, whereas an alternation of periods of rise and fall may be essential if that growth is to remain healthy—that is the ground gained consolidated before a further advance is made.

So far as investment was concerned, this change in character of development was reflected in a sharp fall in the flotation of high-yield railways and foreign government loans, and its place

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taken largely by local private investment of the types indicated above. Both these waves of development involved the metal and capital goods industries, but I cannot help feeling that the transition from the rising price phase to the falling price phase must have caused a discontinuity in the relations between input and output. To employ five years' averages based on the so-called trade cycle must, I suggest, confuse rather than illuminate the situation. The course of the waves I have mentioned can be readily followed in the British figures for export, import and emigration. These waves were not entirely continuous in form but interrupted by minor discontinuities due to the fact that no major innovation ever emerges in its final form or covers the whole field immediately.

The third wave of change covered by the period of Mr. Saunders's data started in the late '90's. It differed from its predecessors in certain novel respects, and this may account in part for the divergencies between Mr. Saunders's metal goods series and the Hoffman production index and its successor in the period after 1907.

A powerful new impulse to development appeared at this time in the shape of the major innovations of electricity and the motor car. The emergence of these innovations was postponed or slowed down in this country until after the war largely because of the new wave of overseas investment and emigration which ensued. Its dramatic effect is vividly depicted in the American figures. It was responsible for the rise of four new major industries—street railways, telephones, electric power and motor transport; with motor transport must be included such major accessories as petroleum, cement, rubber and plate glass. In Britain conditions did not become favourable for technological growth of this kind until well after the war, when home development began to displace overseas development as the prime economic objective.

A major change of this kind does, however, seem to have a very important bearing on the weighting to be given to the various items in Mr. Saunders's metal index.

I agree with him that for Britain the year 1900 was a turning-point in many other respects. A number of industries seemed by then to have passed their optimum point on the curve of improving efficiency, and the impact of other factors such as the changes in the terms of trade and, of course, in the later part of the period, the influence on the metal trade by preparations for war, affected them.

I hope Mr. Saunders will not think that I have trespassed too far outside the orbit of his paper in raising these matters, and that he will find that there is something relevant in them. At the worst I would ask him to treat them as a tribute to the stimulating quality of his paper.

The vote of thanks was put to the meeting and carried unanimously.

Mr. T. S. PILLING congratulated Mr. Saunders on having brought together information from so many different sources on the consumption of raw materials, and for having made so close and interesting a comparison between the input figures into industry and the volume measures of output.

He would like to make two comments on the technical detail of the paper. The first was to note that a rather different treatment had been given to the textile materials from that given to the metals in respect of semi-manufactured products. The measurement of input of the textile materials was at the elementary raw material stage, and out of this consumption came the export of cotton yarn, wool tops and yarns, etc., which might be regarded as equivalent to the semi-manufactures of rods, bars, sheets, etc., which Mr. Saunders had been anxious to eliminate from his definition of the consumption of finished metal. The effect of this different treatment was probably to understate the difference in the trends of activity of the metal-using industries and the textile industries over the half century since 1900. Part of the reason for the relative and indeed absolute decline in the activity of the textile industries had been the decline in exports of tops and yarns, whereas it was probable that the exports of semi-manufactured metals had increased over that period. The point served further to emphasize that we were probably now reaching the zenith of the metal age, whereas the zenith of the textile trade came just before the end of the nineteenth century.

In excluding from the purview of the paper the export of metal semi-manufactures Mr. Saunders had necessarily to ignore a small but quite important sector of the industry. One of the developments of recent years was the growth of fabricating capacity in other countries for the output of finished goods. These countries were looking to countries such as the United Kingdom for their supply of semi-manufactured products.

The second comment was on the effect of stock changes of raw material. When averages over a number of years were given the effect of changes in stocks on the average annual consumption might be quite small, and particularly since the measurement was made in blocks of years running from the top of one cycle to the top of another, the level of stocks generally being lowest at the peak of the cycle. In respect of the early part of the period under review, however, it seemed

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probable that stocks showed a long-term downward trend because of improvements in transport and the general organization of marketing which took place during the second half of the nineteenth century. Another factor likely to have affected the level of stocks in the United Kingdom was the decline of London as the main terminal market of the world in wool, tin, rubber and other materials. London at one time was the main market to which the great bulk of supplies was sent, in part to be later re-exported. The organization of selling markets in the primary producing countries and also, in some cases, on the continent of Europe led to a decline in this trade and in the holding of merchants' stocks.

The effect of these qualifications would be very slight, but when one came to consider the period of the great inter-war depression beginning in 1929, it was clear that in many materials very severe changes in stocks took place. As activity fell off, supplies from current production became surplus but nevertheless continued to come on to the market. As prices fell to very low levels the surplus supplies were taken up by merchants, speculators, or in some cases by firms in the industries. They therefore appeared in the estimates of apparent available supplies and apparent consumption, but they were not taken into consumption until the slump came to an end and recovery began from 1933 onwards. The effect was that the consumption series, based on apparent supplies, probably understated the degree of fluctuation in this period in the activity of the industries concerned. Two particular instances of that could be noted; the first was the figures for tin given on p. 320 where the annual averages were given as 23,000 tons for 1929–32, 9,000 tons for 1933–36, and 26,000 tons for 1937–39. He thought from the general experience of semi-recovery in the tin plate and automobile industries, two of the big tin-using industries, which began around 1933 and went on into the later 1930's, the series hardly represented the actual consumption of tin in the United Kingdom in the period.

Secondly, a comparison was made between volume output in the woollen and worsted industries and fibre consumption. It was said that the index of woollen and worsted output rose between 1930 and 1935 from 70 to 100, but that the index of fibre consumption rose only from 94 in 1930 to 100 in 1935. He thought it improbable that there was any substantial change in the average weight of cloths, etc., which would explain such a disparity, and he would suggest that the explanation was that in 1930 large quantities of wool were imported into this country, at a time of low activity in the industry, to be put away into stock, and only passed into consumption when things became better from 1933 onwards. These were illustrations of some possible divergencies between the apparent consumption series and the true level of activity in particular periods.

The large gain in productivity (in relation to input of raw material) which Mr. Saunders had shown to have occurred in the post-war years was, he thought, encouraging for the United Kingdom's balance of payments prospects. The big expansion in our total exports since 1945 to about 80 per cent. above pre-war, which a very few years ago nearly everybody would have thought would have brought us into a position of balance, had in fact failed to do so, and one of the main reasons had been the tremendous rise in cost of raw materials under pressure generally throughout the world for increased supplies to meet the rapidly increasing volume of industrial output.

If this pressure eased for a while and productivity in use of imported materials continued to gain, the outlook would be better. But so much turned in Mr. Saunders's analysis on the trend in the single material, steel, that it would be unwise to generalize too far.

Mr. A. MAIZELS added his appreciation to that already expressed for Mr. Saunders's paper. He would, however, like to take issue with him on one or two points concerning mainly the analysis of input and output, which was the substantive part of the paper. He would like particularly to refer to Table 3. One knew, he thought, from previous experience of productivity analysis in terms of employment that it was most important in any analysis of this kind to be sure that the things being compared were alike as precisely as one could make them. The two things being compared in this analysis, however, were not precisely alike. On the one hand, there were the metal consumption figures. A glance at the first Appendix would show that the quantities of metal consumption given in Table 3 related to total United Kingdom consumption. On the output side, however, the industries included were not the only industries in the United Kingdom which were important users of these metals. Certain important user-industries were excluded, particularly the railways and the coal mines. From an analysis given in a recent *Bulletin* of the British Iron and Steel Federation it was clear that something like 25 per cent. of total current steel consumption would be accounted for by industries excluded from this table.

Secondly, he would draw attention to the type of total output index which had been used. It would be noticed that it started off with an index number of the volume of gross output for each industry. These index numbers were then weighted, as Mr. Saunders had explained, by the net output of each industry "adjusted for the movement in gross output". The final index for

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the metal-using trades was then combined with the gross output index for building and civil engineering by using metal consumption as weights. He had not worked out the formula for the final output index of 141 for 1935, but it would no doubt be an interesting one.

From what he had said he thought it was fairly clear that the relationship between the index numbers of 141 for output in 1935 and of 116 for metal consumption in that year was not at all a precise one, and the increase in the figure for total "productivity" of metals must have a fairly large margin of error.

He would pass on to consider whether this method of comparing an index of the *weight* of metal consumption on the one hand with an index of the *volume* of output on the other was a very useful and meaningful one.

While the output index took into account the change in the composition of production, the index of the weight of metal consumption did not take into account any change in the composition of input. It was clear from looking at the table that the pattern of metal consumption in the different years was different, and it occurred to him that it might be more correct to compare the index of the volume of metal consumption with the index of the volume of output. It was quite easy to do that from tonnage figures given in the paper plus data on the average price of the metals quoted in any year. The results of this calculation for the years 1935 and 1950 could be set out together with Mr. Saunders's results shown in his Table 5:

	1935	1950
Input		
Weight . . .	100	163
Volume . .	100	188
Output		
Volume . .	100	190

The discrepancy between the weight and volume index numbers for input was due to the tremendous rise in the consumption of aluminium, which was a relatively expensive and light metal. If the two volume figures were approximately comparable, it was clear that the apparent increase of 17 per cent. in "productivity" was due essentially to the change in the composition of input.

He would pass on to the final section of the paper entitled "The Trend away from Self-sufficiency". The paper here defined "self-sufficiency" in terms of weight, and Table 13 was in terms of tonnage. He thought that one could approach the problem once again from the point of view of volume, and the volume concept was a better one since it allowed for changes in the degree of fabrication. In fact, the subject which was dealt with here was one aspect of the change in the import-content of production, and if one studied the figures it seemed clear that so far from there not being a diminution in self-sufficiency, at least for this period, there had been an increase in self-sufficiency in the sense of a reduction in the import-content of production.

He had recently been associated with an investigation into changes in the relation of imports to production, and the final results that had been obtained for the movement since pre-war were as follows:

Volume Index Numbers

	1938	1949
Imports of industrial (non-food) materials	100	107
Industrial production (excluding food processing) . . .	100	129

There were three reasons for the reduction in the import-content of production since 1938. First, there was a long-run tendency, which was apparent throughout the whole period, to a greater degree of fabrication per unit of materials used. Secondly, industries with a relatively low import-content (such as the metal-using industries) had become relatively more important in total industrial output, and industries with a relatively high import-content (such as textiles) had become relatively less important. Thirdly, there had been a very significant degree of substitution in favour of home-produced, or mainly home-produced, materials as against imported materials. Mr. Shone had already pointed out the case of steel being used in place of softwood; the same was true of the displacement of timber by concrete, the ever-expanding uses of plastics and the new developments in petroleum hydrocarbons, to mention some other important examples. All these factors had tended to increase the overall value of work done per unit of material consumed.

The following contribution was received in writing after the meeting:

Mr. J. T. Harris: I should like to make some observations on the wool statistics employed by Mr. Saunders.

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(1) The splitting of the 1929–36 trade cycle into the two periods 1929–32 and 1933–36 has yielded averages of available supplies which are a distorted reflection of the actual average input for processing. Existing data for that period tend to show that 20–25 per cent. of new available supplies was put to stock by the wool industry in the first period and absorbed by it in the second period.

(2) The lack of adjustments for stock movements and the fairly lengthy period of processing of wool textiles appears to have led to erroneous conclusions being drawn from Table 9. Stocks of raw wool were reduced in 1924 and 1935 and added to in 1930. My own estimates of actual clean and recovered wool consumption for processing in 1924, 1930 and 1935 are 506, 400 and 600 million lb. respectively. (These are, in the main, derived from *Dalgety's Annual Wool Review* and the *Census of Production*, 1935.)

The average period of processing for wool from the import to the weaving stage is approximately one year. According to wool consumption statistics, 1935, compared with 1934, was a year of much greater activity; owing to the long period of production the input-output ratio for 1935 is unduly large unless the lag is taken into account. The situation was aggravated by the actual shortage of weavers. There is no evidence of an appreciable change of activity in the industry between 1923 and 1924, so that we are justified in reducing the input for 1935 before making a comparison between input and output in 1924 and 1935. A reasonable figure, representing the average amount of wool worked upon in 1935, would be the mean of the 1934 and 1935 input statistics. This is 553 million lb. The resulting index of fibre consumption would be 91·5, 72·3 and 100 for the years 1924, 1930 and 1935 respectively. These are significantly the same as the output index, and suggest no change of productivity in the wool industry.

Mr. SAUNDERS subsequently replied in writing as follows:

I quite agree with Mr. Shone that the substitution of steel for timber since pre-war years is a factor which may be of some importance and which my measurement of the increase in the "productivity" of steel neglects. Mr. Maizels raised another point of the same nature when he pointed out, with reference to Table 3, that in comparing production in the metal-using industries and building with the total consumption of metals I have ignored the important proportion of steel used elsewhere, e.g., in railway maintenance and coal-mining. Certainly my calculation of "productivity" implies that such uses remain a constant proportion of the total. For the inter-war period this seems to be justified; for example, the proportion of steel used for railways (including rolling stock, which cannot be separated), collieries, and "other" uses was between 22 per cent. and 24 per cent. in each of the years 1924, 1930, 1935 and 1937, the only years for which figures were available (*Monthly Statistical Bulletin of British Iron and Steel Federation*, July, 1950). The proportion going to these uses after the war, according to the same source, was probably rather less, at least in 1949, so that my estimate of the rise in productivity of metals between 1935 and 1949 may be somewhat overstated.

I find it difficult to understand Mr. Glenday's suggestion that the term "productivity" should be restricted to output per *worker*. It is freely used for comparing the output rates of machines. I think it is helpful to widen the term to include productivity of other factors of production.

I am sure that Mr. Pilling is right in pointing out that stock changes often vitiate some of the "consumption" figures for individual years. He instances tin, suggesting that between 1929/32 and 1937/39 true tin consumption must have increased more than my figures suggest. But Mr. J. Ryan's paper on Statistics of Tins and Cans read before the Society on May 28th (e.g., graph 1) shows that U.K. tinplate production was in fact remarkably stable over this period. It is true there may have been bigger changes in the activity of other tin-using industries. I agree, however, with Mr. Pilling and Mr. J. T. Harris that the high apparent wool cosumption figure for 1930 is probably due to stockbuilding. One should really use comparisons only for comparable points in the "short period stock cycle" (to use a phrase which Mr. Glenday may dislike even more than the "trade cycle"). I agree with Mr. Harris that one cannot really deduce any change in the "productivity" of wool between 1924 and 1935.

Of course, as Mr. Maizels very reasonably objected, the methods of compiling output volume indexes (especially in Table 3) are arbitrary, and different methods could give pretty different answers. These very broad comparisons are designed to show the existence and general direction of changes in productivity per ton of raw material input; few index numbers covering longish periods, and measuring aggregates whose composition is changing, can hope to do more. But if changes in this kind of "productivity" are worth measuring, the next stage is to work trade by trade, using the raw material input figures in the Census of Production. This could not be done until the 1948 census became available, and for inter-war comparisons one is bound to use other sources for data about input; such sources normally refer only to total consumption of the material.

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From the 1948 census it should be possible to demonstrate with some accuracy how far changes in raw material productivity are due simply to changes in the pattern of industry and how far to more interesting changes—to see in fact whether there is an underlying constant technical trend, in each industry, towards higher (or lower) productivity per unit of input.

Mr. Maizels pointed to the importance between pre-war and post-war of the changing pattern of industry, especially the shift from textiles to engineering, as a factor making for higher productivity in an even more universal sense—rising productivity per unit of domestic input (labour and capital and home-produced raw materials) per unit of imported input. This is clearly a vital factor reducing our propensity to import and offsetting (although not enough to relieve our troubles) the turn of the terms of trade against us. I think it will be found that the same sort of change applies to the period 1924/29 as compared with 1930/38; between these periods too, and for much the same reasons, industrial output seems to have risen appreciably faster than the volume of imported materials used. But although we have had in the past six or seven years a lower propensity to import raw materials than before the war, there is no evidence that this propensity has been diminishing *during* the post-war period: output and imports have risen about equally. The interesting point now is whether the present depression in the textile industries represents the introduction of another lasting change in pattern.

As a result of the ballot taken during the meeting the candidates named below were elected Fellows of the Society:

Raymond Francis Frederick Dawson.
Leonard Rolfe England.
Alan Huitson.
Danendra Dev Jain.
Jorge Kingston.
Andrew Kirk.
Ronald Arthur Marvin.
Wynne Frederick Maunder.
Joseph Abraham Nissim.
Vera Norris.
Keki Rustom Panthaki.
David Hugh Rawlings.
Lee Hee Seng.
William Brooking Taylor.
William Henry Trickett.
Leslie Thomas Watson.

Corporate Representative

George Paine, *representing* Statistics and Intelligence Division, Board of Inland Revenue.

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Accident Proneness: A Criticism of the Concept Based upon an Analysis of Shunters' Accidents*

By A. M. Adelstein, M.D., D.P.H.

[Read before The Royal Statistical Society, April 23rd, 1952, the President, Professor A Bradford Hill, C.B.E., in the Chair]

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SUMMARY

An analysis is made of 1,452 accidents of shunters. They are generally of a serious nature and the records are considered to be reliable.

The word "accident" can mean many things, and it is wrong to assume that all accidents are comparable. Some fundamental mistakes have arisen because of this confusion. The evidence that the underlying causes of minor accidents are the same as those of major accidents is questioned. This assumption has been one of the corner stones of accident investigations. Often what is being compared is not the having of accidents but the tendency to report accidents, and sometimes completely different types of events are counted together.

Three kinds of accidents in which a shunter is involved are distinguished, viz., (1) those in which the shunter is injured while at work; (2) those in which he is injured at home; (3) those in which he is not injured but in which property is damaged.

It is shown that fatigue cannot be looked upon as a simple phenomenon related only to hours of work.

Age and experience are discussed, and it is concluded that both have an effect in the initial part of the shunter's career and rapidly diminish. Experience is thought to be more important.

* Part of a Thesis for the M.D. at Witwatersrand University.

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Both factors are thought to be operating particularly on the group which is destined to stay on the job for a shorter period; self selection as time passes is an important factor, and the "leavers" have more accidents than the "stayers."

The origin of the concept of accident proneness is traced, and it is shown that this psychological abstraction is based on statistical concepts. The statistical approach is to observe a group of persons equal, as far as possible, in all relevant respects and exposed to the same essential conditions for a period of time. There are great difficulties to be faced in getting such a group. Among other factors are two of particular importance, viz., self selection and equal exposure to risk. Poisson and compound Poisson distributions (as well as other distributions) are fitted to the observed data, and correlations are made in respect of each person's accidents in various periods of time. From the fit of the distributions assumptions are made about the underlying probability models. Some fallacies in this kind of reasoning are pointed out, e.g., there are other ways in which the particular distribution may have arisen.

Various types of accidents can be compared to test inter-relationships, e.g., minor and major, home and industrial injuries. The published work fails to convince that proneness is a consistent factor in an individual in relation to different kinds of accidents.

The statistical techniques are applied to various groups of shunters and the following conclusion suggested:

In regard to injury—during the first year of experience chance factors are enough to explain the data. Those men who have been observed for five years show more evidence that proneness plays a part, and in those 122 men observed for eleven years there is stronger evidence for differing degrees of proneness. But the correlation between different periods is small, and the factor of proneness, although apparently present, is probably of small practical importance—in comparison with chance factors which play a predominant part.

In regard to mishaps which cause damage to property there is good evidence for proneness. In the case of home injuries there is also some evidence.

There is no evidence of correlation between industrial and home injuries, nor between industrial accidents which cause injury and those which cause damage to property. There is no evidence of correlation between minor and major injuries. No good evidence is available that the same men tend to repeat the same kind of accident. When those men who have most accidents in their first year of exposure are compared during the next three years with the remaining men it is found that the mean rates do not differ significantly.

There has been a gradual widening of the original postulates about proneness until now when there is an uncritical acceptance of the erroneous idea that each person has a fixed degree of "accident proneness" in all situations. Even in specific circumstances the situation is being oversimplified and this has resulted in a tendency to neglect the other factors underlying accidents, factors which are not fixed as accident proneness is assumed to be, and are amenable to improvement.

I. Introduction

Accidents in industrialized countries have become the most important cause, with the exception of heart disease, of loss of years of life, and, more startling, they have a greater effect than heart disease has on the national economy (Dickinson & Welker, 1948).

This work was done as part of the author's duties in the South African Railways in order to investigate the causes of accidents among shunters whose work is of a comparatively hazardous nature. During the course of the analysis it appeared that certain assumptions made by recognized authorities were being contradicted by the findings. These assumptions concern primarily the relationship of major to minor accidents, of various types of accidents to one another, and the concept of accident proneness.

It is suggested that the findings show that up to now these concepts have been over-simplified, and that the importance of proneness to injury has been exaggerated, especially when it has been applied as a general law to cover all types of accidents. Furthermore, it is thought that the personal factors underlying serious accidents have never been adequately analysed, and that this work, which is concerned predominantly with serious accidents, might indicate the methods.

The data with which this work is concerned are taken from the files made by the staff section of the South African Railways. It can be said with confidence that the records concerning acci-

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dents and sickness which are kept by this organization are accurate and comprehensive ; one good reason being that moneys paid in place of wages during sickness-absence and for compensation are drawn from separate accounts. This results in a check of the facts by the accounting department as well as by the individual who has to receive the money. This double check gives the author added confidence in presenting the data, because a perusal of the literature on the subject indicates that frequently the data are taken from a source such as records kept in a dressing station, and there is no evidence as to the comprehensiveness or accuracy of these records.

The accident records are especially good because details are kept in order to meet the requirements of the Workmen's Compensation Commissioner as well as for purposes of accident prevention.

II. Problems of Classification

In a statistical analysis it is essential to define as precisely as possible what is being analysed. For instance, the word "accident" has been used in many senses, and this had led to confusion in comparing and analysing statistics.

An error of this kind will be referred to as an error in classification. There appear to be three important errors of classification which have affected conclusions of a fundamental nature, viz.,

1. The classification of major with minor accidents.
2. The confusion of the tendency *to report* accidents with the tendency *to have* accidents.
3. The use of the word "accident" to mean entirely different events, viz., in one case personal injury and in the other case damage to property.

(1) *Classification of Major with Minor Accidents*

This factor is important, because all the authors on the subject of accident proneness, to be mentioned later, have accepted the conclusion that these two aspects are positively and highly correlated. The arguments and evidence which they have used will be dealt with fairly extensively, and it is suggested that the conclusions are not warranted from the evidence. Furthermore the assumed positive relationship has occupied a fundamental position in the work on accident proneness, as the following quotations from the leading authors will show :

The Medical Research Council in its publication, *The Personal Factor in Accidents* (1942), states :

> "*The relation between major and minor accidents.*—The accident records of some 14,000 workers, comprising several different trades, were analysed, and it was found that, in most of the trades, those who had an undue number of minor accidents also had an undue number of major accidents. This implies that those specially liable had more accidents, both minor and major, than others with a lower degree of liability.
>
> "This adds to the practical value of our knowledge about the distribution of accidents, for although the distributions examined mostly refer to minor accidents, any conclusions arrived at will apply also to major accidents. The gravity of an accident depends largely on chance circumstances—for example, the part of the body injured—so that naturally any peculiarities in the distribution would be common to both major and minor accidents. Efforts made to prevent people specially susceptible to accidents from incurring danger will tend to protect them not only from minor accidents but also from major ones".

Greenwood and Woods (1919), the pioneers of the idea of accident proneness, stated:

> "The law of distribution will not in general be affected by the consequences attaching to the results. The number of sixes thrown with a pair of dice in a hundred trials will not be affected by the height of the stakes. Hence if we are warranted in referring the distributions here discussed to the factor of individual susceptibility, we can have no hesitation in thinking that the same principle may apply to the genesis the results of which whether to the individual or the plant may be grave".

Newbold (1926) states :

> "We look on them rather as some measure—inadequate though we know it to be—of a vague quality which we will examine more closely as we go on and which we may call

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'tendency of accident'. Such a tendency leads to certain events: in 99 cases out of 100, say, the consequences of these events may be of little or no importance, in the hundredth they may be disastrous, hence the seriousness or triviality of the consequences bears in general no relation to the exciting causes".

In the preface to the Industrial Fatigue Research Board Report No. 19 the authors (1922) state:

> "The important practical conclusion follows that for certain purposes the *effects* of accidents may be left out of consideration when studying their causation".

Slocombe (1937) has given evidence which purports to show that 48 men in a plant employing 6,600 men had a high incidence of minor accidents, and in major accidents they had fifteen times as many as the average for all employees.

These concepts can be criticised as follows:

The statement above made in *The Personal Factor in Accidents* refers to the report of Farmer and Chambers (1926), who analysed the records for a year of 14,524 dockyard workers comprising various trades. A major accident was defined as one involving one day or more lost time. The figures were analysed in 10 groups; coefficients of correlation between major and minor accidents were 0·138, 0·170, 0·252, 0·254, 0·311, 0·356, 0·055, −0·039, −0·022, −0·004, the last three being not significant. Now these correlations are small, and it seems probable that they are due to an overlap of the "tendency to report" because the criterion for serious accidents is low, and it is probable that some persons would stay away for injuries which others would not trouble to report at all.

In the same report the authors say:

> "Moreover, from a psychological point of view an accident is merely a failure to act correctly in a given situation, and the relative gravity of the result of such a failure must be regarded as irrelevant, *except insofar as fear of* (*or indifference to*) *the consequences may influence the action leading to an accident*". (Our italics.)

Farmer and Chambers maintain that fear or indifference to the consequences is the exception, but it is suggested that there is no evidence for this assertion and that it may well turn out that fear or indifference to the consequences are indeed major factors leading to an accident.

The analogy of the dice is not well chosen. The stakes in a game of dice may not affect the number of sixes thrown, but the possible consequences of an accident may well affect the prior actions of the worker. His whole attitude and approach to the job may alter according to the known danger inherent in the job.

The difficulty about Slocombe's findings is that he does not state on what basis the 48 men were selected for analysis; whether in fact their exposure to danger was the same as that of the other workers.

It is felt that the authors mentioned are not justified in concluding that the underlying factors of major and minor accidents are correlated. In Chapter V on Accident Proneness a similar analysis to that made by Chambers is described for 304 men over five years. The correlation of major and minor accidents, using six days of absence and less as the criterion for minor accidents, is shown in Table 13. The coefficient of correlation is ·1023 and is not significant. It seems that more practical examples of this kind are needed before such positive theoretical conclusions as those mentioned above are made, and furthermore that in some occupations minor and major accidents are not correlated.

(2) *Confusion between the Tendency to Report Accidents and the Tendency to Have Accidents.*

A point which has been made frequently but which has not received sufficient attention is the question of which accidents are reported and which not. Greenwood and Woods in the report mentioned state:

> "But the nervous or ultra careful woman may, for various reasons, report accidents which the average woman would disregard altogether."

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In spite of the fact that these authors were aware of the tendency to report, they did not attach sufficient weight to it in their conclusions. There may be other motives, too, in reporting trivial accidents to a first aid station; for instance, wasting time may be one. In fact often what is measured is the tendency to report trivial accidents rather than the tendency to have these accidents.

(3) "*Accident*" *Used to Mean Different Events*

A further problem of classification in accident statistics which may cause confusion is the tendency to include in the term "accident" entirely different aspects of the event: injury to the worker, damage to property, and injury to other persons. These three aspects of accidents are especially noticeable in the transportation industry. The differences have been pointed out by Viteles (1932), but here again the conclusions seem to be unwarranted. He says:

> "At the same time the objective circumstances and surrounding personal conditions of the transportation accident resemble closely those which are found in cases of injury to the worker in the industrial plant. There is good reason to believe that the incidence of accidents in the transportation industry is determined by the same factors and governed by the same laws which account for personal injuries in the manufacturing plant".

Viteles does not state what these good reasons are, and on *a priori* grounds one would hesitate to accept this conclusion. In fact one might expect that the tendencies to injure oneself and to injure others may be entirely different aspects of personality, and that to damage property may be still a third aspect.

The present paper breaks new ground by dealing with data derived from industrial accidents, the large majority of which are serious, and further in presenting data of three kinds of accidents sustained by the same men, viz., industrial injuries, home injuries, and accidents resulting in damage to property. The nature of shunting is described later. It will be seen that during most of the work an accident is liable to have serious consequences.

III. Shunting Accidents which Result in Personal Injury

Description of Data

The data with which the investigation deals are taken from all the personnel records of men who were shunters at any time during the period January 1st, 1943, to December 31st, 1947, on the Western Transvaal System. The facts concerning accidents and sickness on these records could be traced back to 1937. Where necessary, for statistical purposes, those men who were on active Service are excluded.

Preliminary examination of the records showed that many shunters work for short periods, so that there is a rapid turnover of the labour force. This makes for statistical difficulties, because many of the statistical techniques require that there should be a constant period of exposure of the same people to the same hazards. Various methods have been used to try to overcome this difficulty, and they will be described as they are used.

The reporting of accidents is based on the provisions of the Workmen's Compensation Act, Act 30 of 1941. In this Act an "accident" means an accident arising out of and in the course of a workman's employment, and resulting in personal injury. The Act further states:

> "In order that compensation may be obtained under this Act, written notice of the accident, in the prescribed manner, shall be given by or on behalf of the workman to the employer as soon as is reasonably possible after the accident".

Officers' and employees' staff regulations of the South African Railways make provision for this Act, and Form G.141 is provided for the reporting of accidents.

It is considered that the answers on these forms are reliable in the vast majority of cases except for the question as to whether or not a coupling stick was used.

One problem of classification which still arises is the lower limit of seriousness of accidents All the accidents reported in fulfilment of the requirements of the Workmen's Compensation Commissioner have been included. A Proportion of these (13·6 per cent.) caused a minor disability that did not necessitate staying away from work, and here the problem raised above appears—

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one man might report what another ignores. Of course this problem cannot be solved altogether, because if only those accidents were counted which caused absence from work, there would still arise the fact that for the same injury, one man may stay away from work whilst another would not. However, this classification is much more definite than those in the reports mentioned in the previous Chapter in that few accidents cause no lost time and the majority are serious. Another factor is that the requirements for reporting are fairly strict. The form must be filled in, a witness of the accident must be called and a controlling officer is required to verify it, while an authorised medical practitioner must certify the injury. Under these circumstances it is not likely that what is being measured is the tendency to report rather than the tendency to have accidents.

The discussion up to this point is concerned only with work injuries. The other aspect of accidents concerned with damage to property is dealt with in Chapters IV and V. This is an extremely important aspect as far as a transportation industry is concerned. It will be noted that a large number of these mishaps occur and the financial loss incurred due to damage and disorganisation is considerable.

A point which requires consideration, especially in regard to the problem of accident proneness, concerns "equal exposure to risk". Absolute equal exposure cannot be realized in practice. There is no means of measuring the output of each shunter, but it is confidently expected that, practically speaking, they perform equal work during an equal time period, especially when the time observed is of some length, e.g., one year.

Observations about Shunting

Shunting is associated with a high accident rate. This is shown by the fact that over a period of two years May, 1947, to May, 1949, the number of shunters who were receiving monthly Injured on Duty pay varied between 11 per cent. and 21 per cent, of the total number of men receiving Injured on Duty pay, while the total number of shunters is only 7 per cent. of men on the system concerned.

Shunting is an occupation which involves a large number of activities in contrast to those occupations where workers perform a somewhat simple repetitive action. The shunter spends a good deal of time walking and running along the surface of the shunting yard. In doing so he may injure himself by tripping or stumbling over objects on the ground, or he may come into contact with stationary objects or be hit by moving vehicles. He spends some time riding on the outside of trucks and coaches. He jumps off and on the moving vehicles, and in so doing he may injure himself by falling or in other ways. He manipulates the buffers which connect the vehicles, and he may be injured by the bumping together of these vehicles, or by the mere manipulation of the heavy iron components involved. He has to manipulate brakes and vacuum pipes and points, and he is exposed to flying particles of dust and coal dust. Accidents are liable to be severe, maiming, and occasionally fatal. The nature of the various operations will be further analysed later.

The period mainly concerned (1943–1947) embraces part of the war years and the boom times which followed. Railway working was continually increasing, there was a shortage of man power and a good deal of overtime was worked. It is probably true to say that almost all the shunters were working twelve-hour shifts for almost all their shifts.

The Population dealt with

The records show that on January 1st, 1943, there were 595 shunters, and on December 31st, 1947, there were 961. The number of persons who left during this period was 577. There was a fairly steady rise of personnel month by month. Altogether 1,442 persons are involved in the analysis, but at different times during the five-year period.

Age Distribution

In Table 1 the age distribution of the men is shown as it appeared on two occasions, that, is January 1st, 1943, and December 31st, 1947. There is no significant difference between the means of these two distributions. The range is from 20 years to 60 years. The mean age in January 1943, is 32·84 years and in December, 1947, it is 32·59 years. The standard deviations are 7·6 and 6·85 years respectively.

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TABLE 1

Showing the Age Distributions of Shunters on the First and Last Days of the Investigation.

	Shunters			
	At January 1st, 1943		At December 31st, 1947	
Age in years	Number	Per cent	Number	Per cent
21–25	82	13·71	139	14·33
26–30	191	31·94	254	26·18
31–35	149	24·91	303	31·24
36–40	91	15·22	166	17·11
41–45	33	5·52	64	6·59
46–50	33	5·52	24	2·47
51–55	15	2·51	13	1·34
56–60	4	0·67	7	0·72
Total	598	100·00	970	99·98
Mean age	32·84 years		32·59 years	
Standard deviation	7·6 ,,		6·85 ,,	

The Nature of the Injuries

These are classified according to the limb injured and the nature of the injury in the two tables below. 1,442 persons are involved during the five-year period 1943–1947.

TABLE 2

Accidents Classified According to Limb Involved and Type of Injury

Limb Involved	*Number*	*Type of Injury*	*Number*
Fingers	499	Fracture	76
Hand	147	Amputation	91
Forearm	36	Crushes	125
Arm	26	Lacerations	183
Head	64	Cuts	44
Shoulder Girdle	25	Bruises and Contusions	463
Abdomen	11	Wounds and Abrasions	107
Pelvis	6	Sprains and Strains	278
Thigh	38	Foreign bodies in Eyes	63
Leg	88	Unclassified	22
Knee	98		
Ankle	156		
Foot	91		
Back	60		
Eye	8		
Eye (Foreign Body)	63		
Others	9		
Thorax	27		
Total	1,452	Total	1,452

TABLE 3

Classification According to the Number of Days Off Duty for Each Accident

Days off Duty	*Number of Cases*
0	199
1– 10	811
11– 20	241
21– 30	108
31– 40	73
41– 50	58
51– 60	48
61– 70	31
71– 80	24
81–313	58
Total . 28,041	Total . 1,452

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There were 9 deaths and 211 persons were declared permanently disabled in some degree although the disablement may be minor in some cases, e.g., the loss of the tip of a finger is a permanent disablement of about 2 per cent.

Effects of the Injuries

Costs.—It is not possible to estimate the costs accurately but some minimum direct costs are given.

(1) Lump sums paid for permanent disablement	£11,700
(2) Monthly pensions begun for permanent disablement caused during this period	£170 p.m.
(3) I.O.D. pay for working days lost (approximately)	£500 p.m.
(4) Varying amounts for pensions to widows and children of 9 shunters killed	..

The direct costs are not the whole cost by any means. They do not include costs due to damage to equipment and property, nor those hidden costs caused by lost time of supervisors, investigators and persons who assist at the accident. Most investigators estimate the indirect costs to be much higher than the direct costs.

The Personal and Social Effects

It is difficult to be precise, but it is reasonable to suppose that there may be far-reaching effects on the physical and psychological health of the individual who sustains a serious accident quite apart from the actual disablement. The effect on the morale of the whole group is appreciable and adds to the general unattractiveness of the job. There are, too, effects on the family, due to economic upset and loss, and to the anxiety.

The Nature of the Accident

The description of the accident is given on the accident report form; usually by the shunter himself, if he can give it, or by his controlling officer, and is verified by the officer in charge. As mentioned previously, we believe that the basic information on these records is true. The accidents have been divided into various types according to the activity which was being attempted at the time. The results are shown in Table 4. The percentage of the total number of accidents is shown for each type as well as the days away from duty, the number of deaths, and the number of permanent disablements.

"Coupling" accidents form the largest single group, being 29 per cent. of all the accidents. Nearly one-third of these accidents result in permanent disablement, i.e., partial permanent disablement such as an amputated finger. The average time off duty is 33 days per accident. As is to be expected, the great majority of these accidents result in crushes, fractures, amputations, lacerations, etc., of the hands. There is one death in this group.

A detailed analysis of these accidents is attempted below. Basically there are two types of buffers, the old bell type and the new patent type. The new type of buffer is apparently much safer than the old. Of the 423 coupling accidents reports, 155 mentioned the type of buffer involved, although this information is not specifically asked for. There does not appear to be any special reason why one type of buffer is mentioned rather than another, and hence the assumption is made that these 155 cases give a true reflection of the actual proportion of type of buffer involved in accidents.

In examining these figures it is necessary to take into account the number of each type of buffer present. During the five-year period under review there was a continual increase in the number of trucks together with an increase in the proportion of patent buffers which are being introduced as a general measure. In 1943 the number of patent or automatic buffers was 72 per cent. of the total and it steadily increased until 1947, when it was slightly more than 78 per cent.

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TABLE 4

Accidents Classified According to the Nature of Activity Performed—1,451 *Accidents* 5 *Years*

Nature of Activity	*Number of Accidents*	*Percentage of All Accidents*	*Average Days Off each Accident*	*Number of Deaths*	*Number of Permanent Disablements*
1. *Coupling*					
With 2 patent buffers	23	—	—	—	7
With 1 patent and 1 bell buffer	108	—	—	—	38
With 2 bell buffers	24	—	—	—	10
With unrecorded types of buffers	268	—	—	—	92
Total	423	29·15	33	1	147
2. *Uncoupling*					
With 2 patent buffers	15	—	—	—	1
With 1 patent and 1 bell buffer	10	—	—	—	1
With 2 bell buffers	2	—	—	—	—
2 unrecorded types of buffers	49	—	—	—	6
Total	76	3·7	18	1	8
3. *Jumping on and off moving vehicles*	229	15·7	14		—
4. *Tripping and stumbling*					
Over rails and points	62	—	6	—	—
Over signal wires and fittings	17	—	11	—	—
Over loose objects	71	—	10	—	—
Total	150	10·3	8·46	1	
5. *Adjusting buffers prior to coupling*	85	11·8	12	—	1
6. *Adjusting buffers and hit by oncoming vehicle*	87		27	—	29
7. *Adjusting brakes while riding*	38	2·8	14	—	—
8. *Adjusting brakes while on ground*	56	3·8	9	—	—
9. *Foreign body in eye*	64	4·4	4	—	
10. *Coming into contact with other objects while riding*	16	1·1	23	1	1
11. *Manipulating vacuum pipes*	7	·48	10	—	—
12. *Burnt by steam from engine*	2	·13	7	—	—
13. *Details not known, but coupling or uncoupling*	50	3·4	12	1	2
14. *Standing clear or walking and hit by another moving vehicle*	13	·9	—	3	—
15. *Hit by truck door*	17	1·17	—	—	—
16. *Turning points by means of tumblers*	22	1·43	—	—	—
17. *Riding on trucks and injured by movement of goods in truck*	6	—	—	—	—
18. *Not classified*	110	8	—	1	9
Total	1,451	100	19	9	211

If one assumes that there were 75 per cent. of automatic buffers among about 50,000 vehicles, and further that these buffers are distributed and come into shunting use in a perfectly random way, then the comparison of actual and expected accidents would be:

	Observed Number of Accidents	*Expected Number of Accidetsn*
2 Automatic buffers	23	87·2
2 Bell type buffers	24	9·7
1 of each type	108	58·1
	155	155·0

$\chi^2 = 110$ $P < \cdot 001$

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The differences are significant. The greater danger appears to be about equally manifested in a combination of 2 Bell buffers or a combination of one bell buffer and one automatic type.

In both cases there are about twice as many accidents as expected on the hypothesis of equal liability of all buffers, but it is clear that the number of bell type buffers is rapidly diminishing, so that a combination of two such buffers is becoming rare, whereas a mixed combination is still quite frequent and will still account for a large number of accidents.

As the proportion of automatic buffers increases above 80 per cent., so the number of accidents which occur at the buffers during the compiling process should diminish rapidly. These accidents, during coupling and uncoupling, at present form over 30 per cent. of accidents, and as these accidents are of a serious nature a great benefit in this respect will accrue when this gap is bridged.

Monthly Accident Rate

Because the number of shunters varies from month to month the monthly accident incidence is expressed as a rate, i.e., the number of accidents per man. A slight error occurs in that the number of men is counted as those employed on a particular day of the month. The monthly

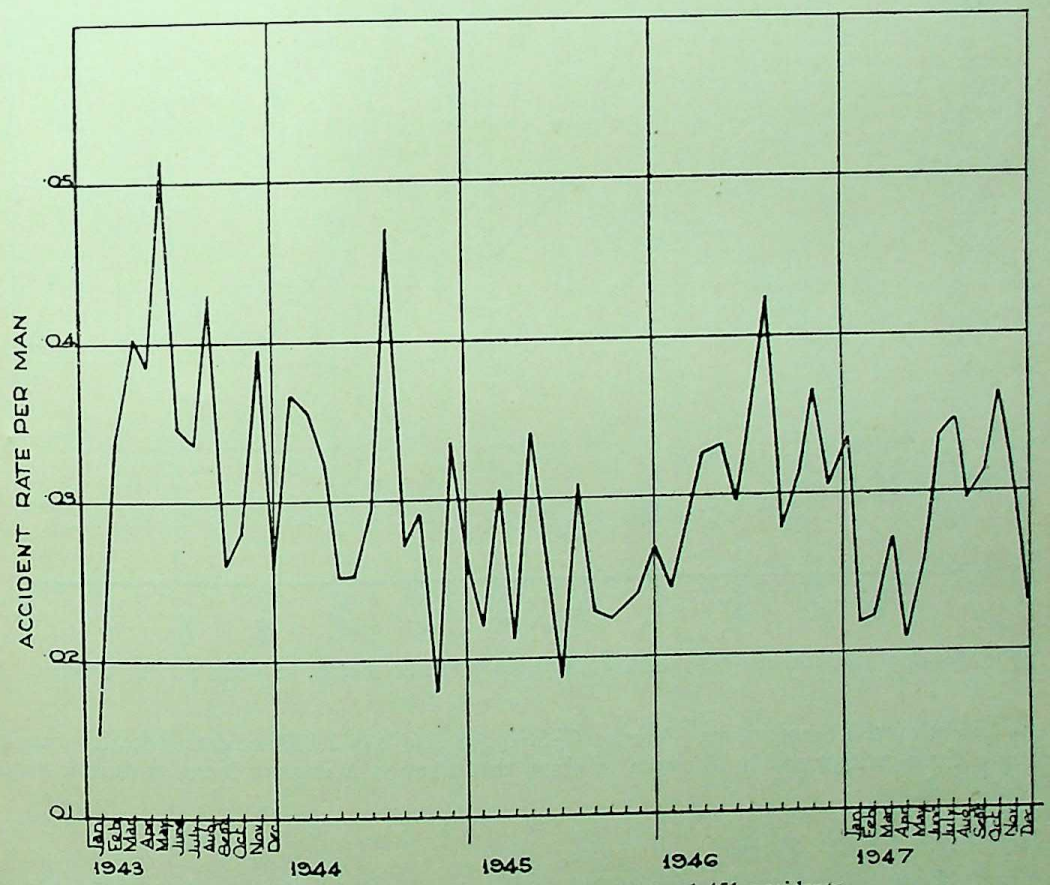

FIG. 1.—Monthly accident rate per man. 1,451 accidents.

rate shows a fluctuation varying between ·0151 and ·0516 per man as shown in Fig. 1. When the equivalent months of each year are summed as shown in Fig. 2, a suggestion of a trend appears showing a tendency for the rate to be lowest during the summer months and to rise to a peak in July.* As will be pointed out in the chapter dealing with sickness, there is an increase of sickness absence during the winter months. This has frequently been suggested as the reason for the

* The South African winter is at its peak in June and July.

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increased accident rate, but there is no evidence that this is a fact. As pointed out later, there is no correlation between accidents and number of sicknesses. Possibly the cold and inclement weather has an effect on the dexterity of the shunters. Another possibility which may be considered is the fact of less natural light during the winter months.

With regard to the effect of weather in other occupations we have the data of an investigation in the United States of America mentioned by Rawson (1943). More than 1,400 drivers were investigated, and it was found that the majority of accidents take place in clear weather although only one-third of the days of the year are clear. Osborne and Vernon (1922) investigated workers at three munition factories, and found that the number of accidents (cuts) experienced was greatly influenced by the temperature with a minimum number of accidents at 67°F., the number increasing

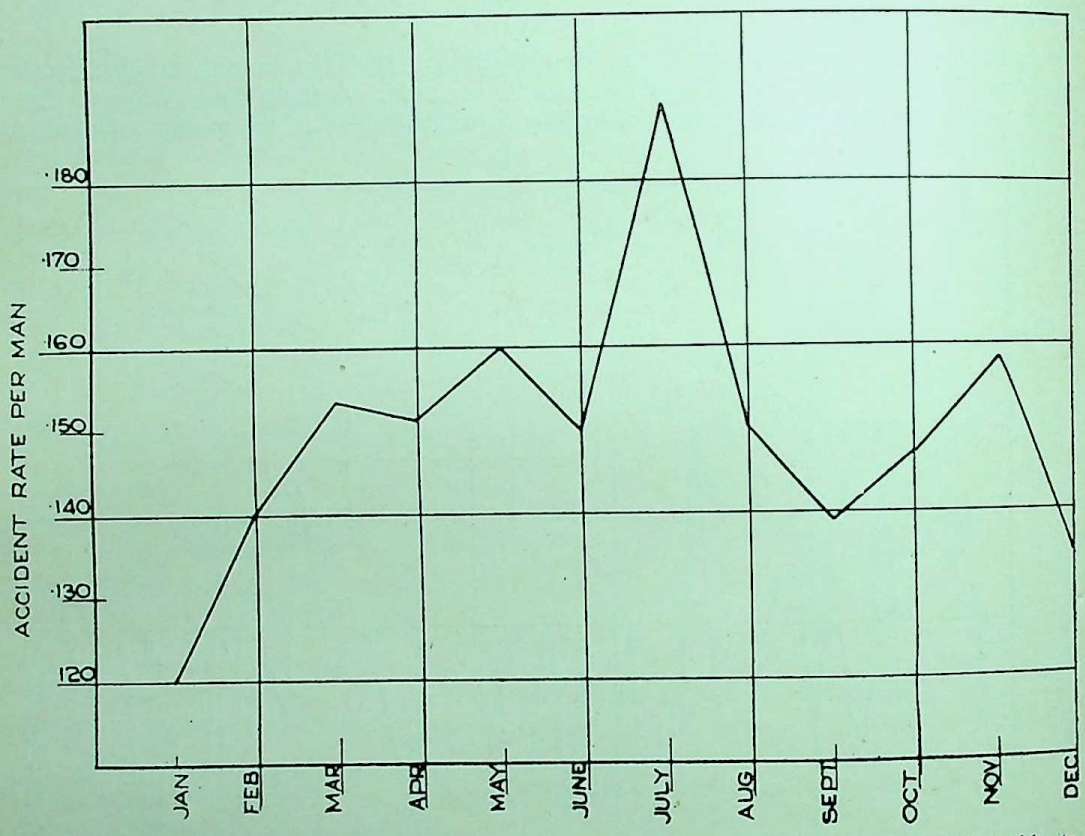

FIG. 2.—Accident rate per man summed for each calendar month. 5 years ; 1,451 accidents

above and below this temperature. Vernon (1936) gives details of 2,100 accidental deaths observed during a three-year period in America to show that there is a distinct increase during winter months.

Hourly Accident Rate: Fatigue

Fig. 3 shows all the accidents according to the time at which they occurred. Shunting is organized in shifts, beginning 6 a.m., 2 p.m., 6 p.m., and 10 p.m., each lasting eight hours, and frequently overtime was worked up to twelve hours. Occasionally shunters began at non-scheduled times. Figs. 4, 5, 6 and 7 reflect the curves for each shift, and Fig. 8 is the curve for all the accidents in relation to the time spent at work. To interpret these curves one must bear in mind that the amount of overtime worked was not constant, so that the figures of accidents after eight hours refer to fewer hours of exposure than those up to eight hours.

The factors which underlie the shape of the curves are not clearly understood. Two concepts are to be reckoned with, the amount of work done in each hour, and fatigue. Osborne and

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Vernon (1922) have shown that during the day shifts there is a clear relationship between accidents and output. This relationship would seem to be obvious in that more work done makes more opportunity for injury. With regard to the shunters, this factor could not be properly evaluated because of absence of output figures, but in general during the years dealt with the traffic was very heavy, and the output of work is thought to have been reasonably constant for each shunter.

The concept of fatigue when applied without further definition is extremely vague, because it is obvious that there are many different aspects of fatigue. While one function of the body might be fatigued, another may be alert. The subjective feeling of fatigue may bear no relationship

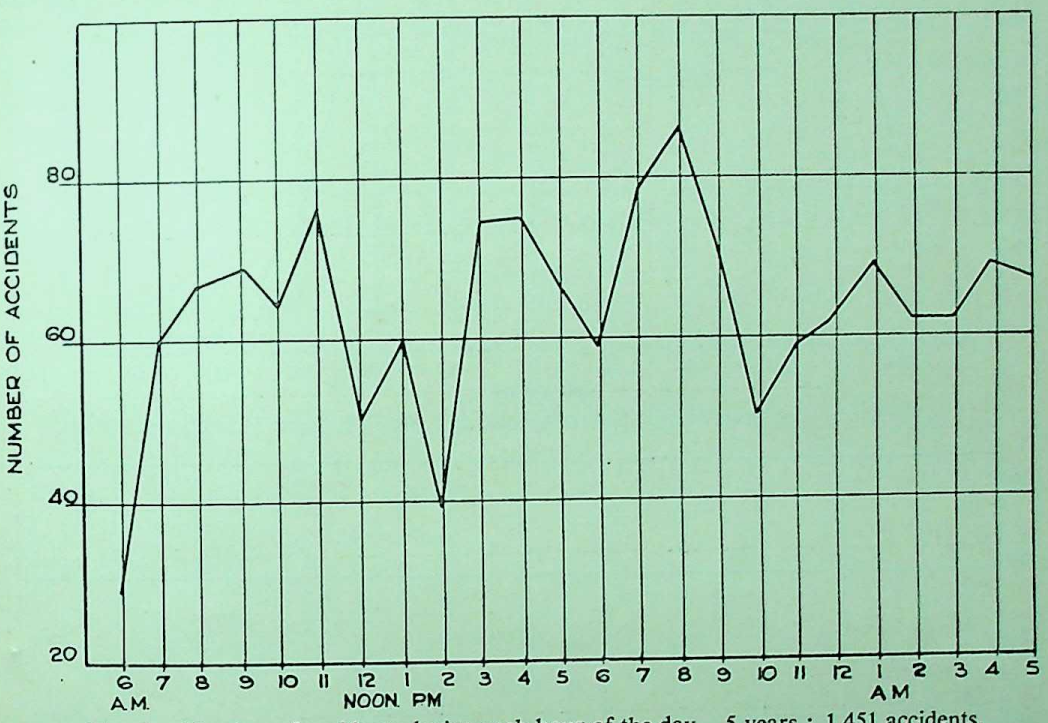

FIG. 3.—Number of accidents during each hour of the day. 5 years ; 1,451 accidents.

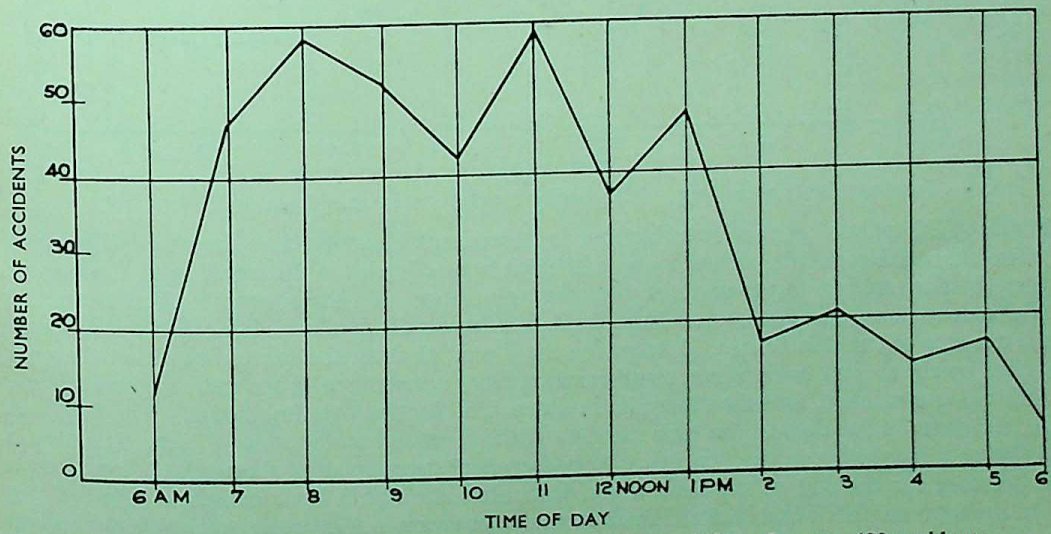

FIG. 4.—Accidents each hour, of men beginning at 6 a.m. shifts. 5 years; 429 accidents.

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to the amount of rest or work done. It is pointed out by Ghiselli and Brown (1948) that circular reasoning with regard to fatigue is particularly evident when fatigue is offered as a cause of accidents. If the hourly rate moves upward with time, then this is said to prove that fatigue is the cause; if the rate does not move upward then it is contended that fatigue is not acting in the particular instance.

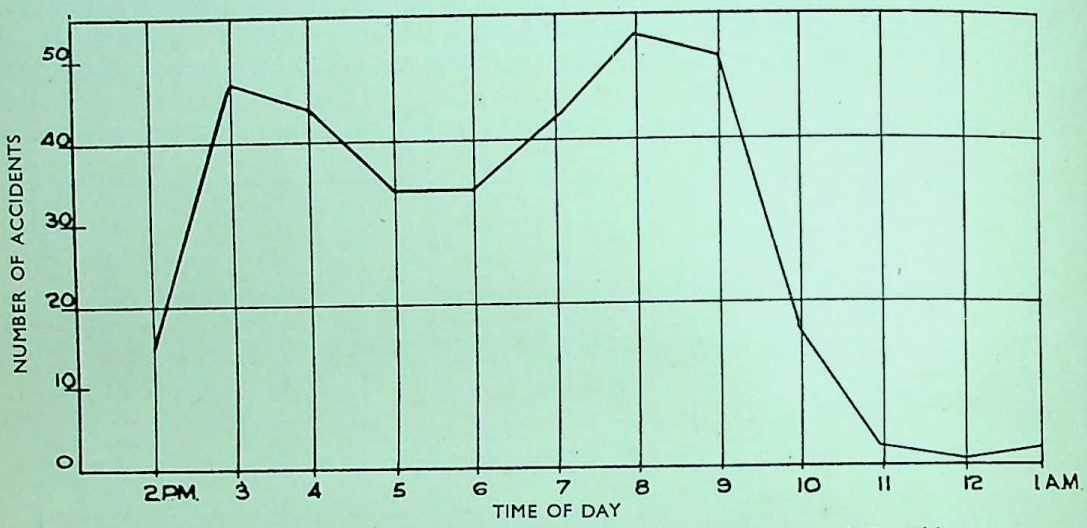

FIG. 5.—Accidents each hour of men beginning shift at 2 p.m. 5 years; 345 accidents.

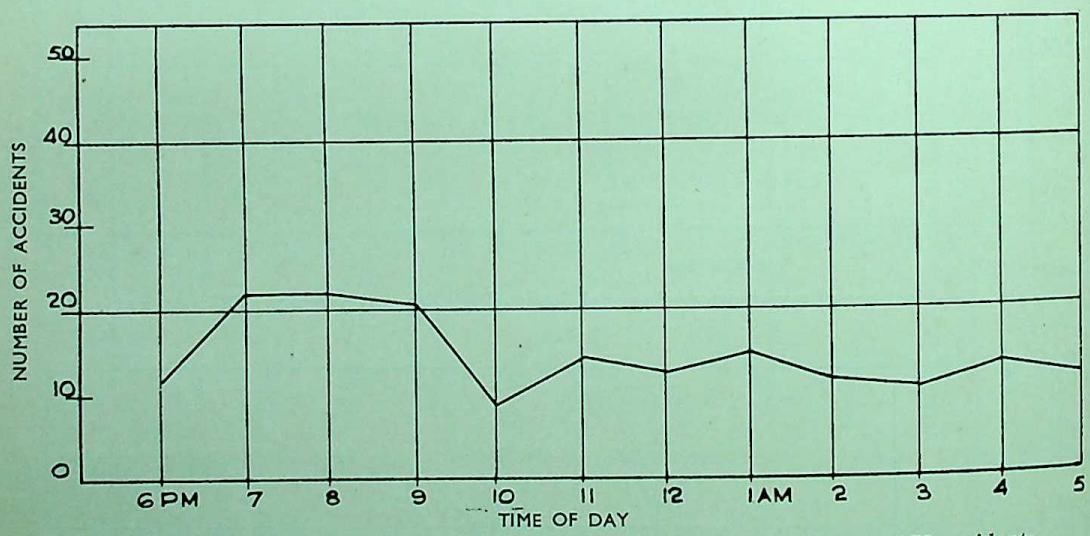

FIG. 6.—Total accidents each hour. Men beginning shift at 6 p.m. 5 years; 178 accidents.

Viteles (1932) points out that investigations in America and Europe have shown a fairly typical curve for industrial accidents, having a rise with each hour of work in the morning to a maximum at about 11 a.m. and falling towards zero at the noon hour. In the afternoon there is another rise with a drop during the last hour. Shunters do not have a defined lunch hour, and this accounts for the absence of the double rise. Except for the 6 p.m. shift all the curves show that the peak is reached by the second hour of work and remains fairly constant or drops until the seventh and eighth hours are reached, and then there is a sudden drop for the overtime hours. Fig. 8 reflects all the accidents in relation to the time on duty without regard to the time of day. It shows a rapid rise to a maximum in the first hour, then a gradual decrease until six hours, followed by a rapid decrease for the rest of the shift. Accidents after the eighth hour comprise only 8·7 per cent. of the total number of accidents. Because the exact amount of overtime worked is not known there can be no accurate comparison, but the overtime is known to have been almost a constant

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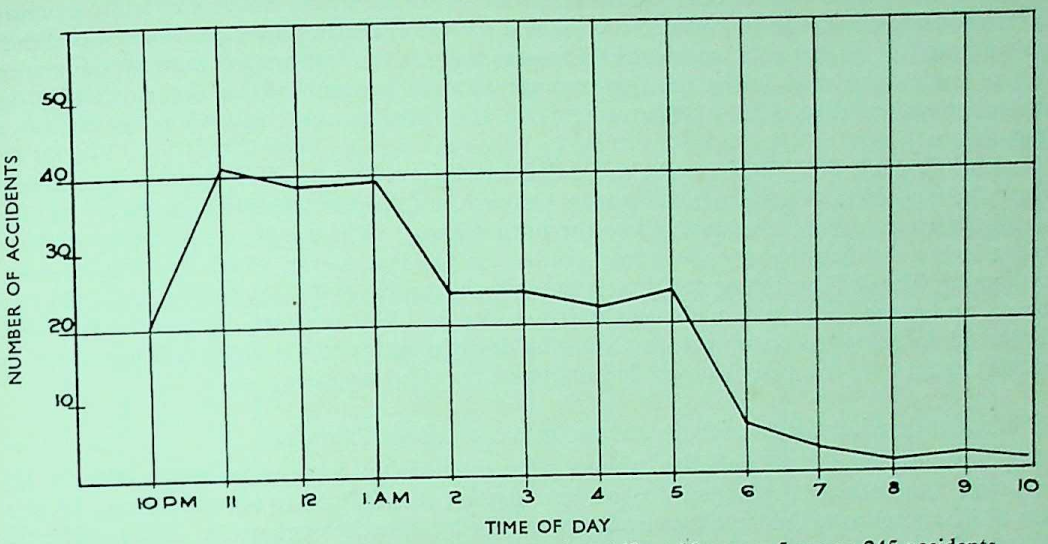

FIG. 7.—Total accidents each hour. Men beginning shift at 10 p.m. 5 years; 245 accidents.

FIG. 8.—Accidents in relation to time worked. 5 years; 1,451 accident.

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feature and the shifts were virtually twelve-hour shifts, so it can be said confidently excessive accidents did not occur during "overtime". This does not mean that the extra hours worked did not have an effect on the total accident rate for the period. A fact against this last contention, however, is that the rate during the five-year period was reasonably constant, suggesting that there was no cumulative effect of overwork. This is so for "stayers" as well as for the whole population.

Night shift work does not have the same characteristics with regard to output and accidents as does the day shift. This is pointed out by Osborne and Vernon (1922) when they show that the accident rate at night does not follow the output curve. The 6 p.m. and 10 p.m. shifts of shunters have a distinct drop for the second half of the accident curves, which are noticeably low throughout. The shift beginning at 2 p.m. is the only shift with a rise in the second half, beginning at 6 p.m. and rising until 8 p.m. with a slight drop to 9 p.m. The obvious difference between this and other shifts is that the men work partly during daylight and partly at night, and it is suggested that this change over from day to night has an unsettling effect on them.

The Relationship of Accidents with Age, Experience and Labour Turnover

Many reports have been published showing the relationship between accidents and age and experience. As both age and experience increase together it is difficult to separate them. A third factor which complicates this issue is caused by persons who leave the work early. It is possible that they leave for reasons concerned with their accident liability, e.g., men may leave because they feel unsafe or uneasy at the work, and these may be men who if they had stayed would have had a high accident rate. If a process like this is occurring the population left is a selected one having those shunters who are less liable to accident. One may also reason that there are common factors which render a man both liable to accidents and to change jobs readily. Newbold (1926) found that the accident rate tended to decrease with age and experience and that age apparently played the predominant role. Farmer, Chambers and Kirk (1938) found that this was so for dockyard apprentices living under normal industrial conditions, but that the accident rate of the R.A.F. apprentices living in barracks tended to increase with age and experience. However, there was a distinct difference in these groups in that the dockyard apprentices suffered financial loss for absence and the R.A.F. apprentices did not. Furthermore it should be repeated that these findings refer to minor injuries. The same authors give the figures for two other industrial groups and conclude:

> "These figures tend to show that a decline in accident rate with age is normal for industrial groups, and that the rise of accident rate with age for Service apprentices is peculiar and probably connected with their different terms of employment".

Vernon (1936) has given examples showing the influence of age and experience on the accident rates in various occupations. Generally there is a diminution of the rate with age and experience especially marked at the beginning of the experience, but he also gives evidence to show that the average period of disablement resulting from each accident increases with increase of age. Ghiselli and Brown (1948) publish figures for trolley-car motor men for the first nineteen months of their employment:

> "By the end of the fifth month on the job their accident rate was halved and by the end of the nineteenth month it was reduced to about one third."

The same workers found that "when experience was held constant the relationship between accidents and age was almost zero". This contrasts with Newbold's finding mentioned above. Viteles (1932) quotes from four publications which are also in conflict with Newbold's finding concerning experience and he ends by saying:

> " . . . such data suggests that experience is a factor in accident causation. However, there is need for a very intensive analysis of this relationship to determine more exactly the influence of age, of levels of proficiency of selection, of temperamental reaction to new surroundings and conditions of work, and of other mental factors which may be concealed in a general cover-all of experience".

An attempt is now made to measure the factor due to "self selection" mentioned earlier in connection with men who leave the work early in their careers. Three groups of men are compared

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in Fig. 9. Firstly those who are known to have left within four years. This group is followed for only one year because the number of men becomes too small thereafter; secondly those who do not leave for at least three years; and thirdly those who do not leave for at least five years. Fig. 9 shows the curves of the quarterly accident rates for these groups. Section A represents a diminishing number of persons from month to month. Hence the rate is worked out for a smaller number each month. Sections B and C have a constant number of men throughout. The lines are simply guessed trends.

In Section A the three factors mentioned above cannot be accurately separated, but it seems extremely unlikely that age can play a major role in the downward tendency seeing that only one

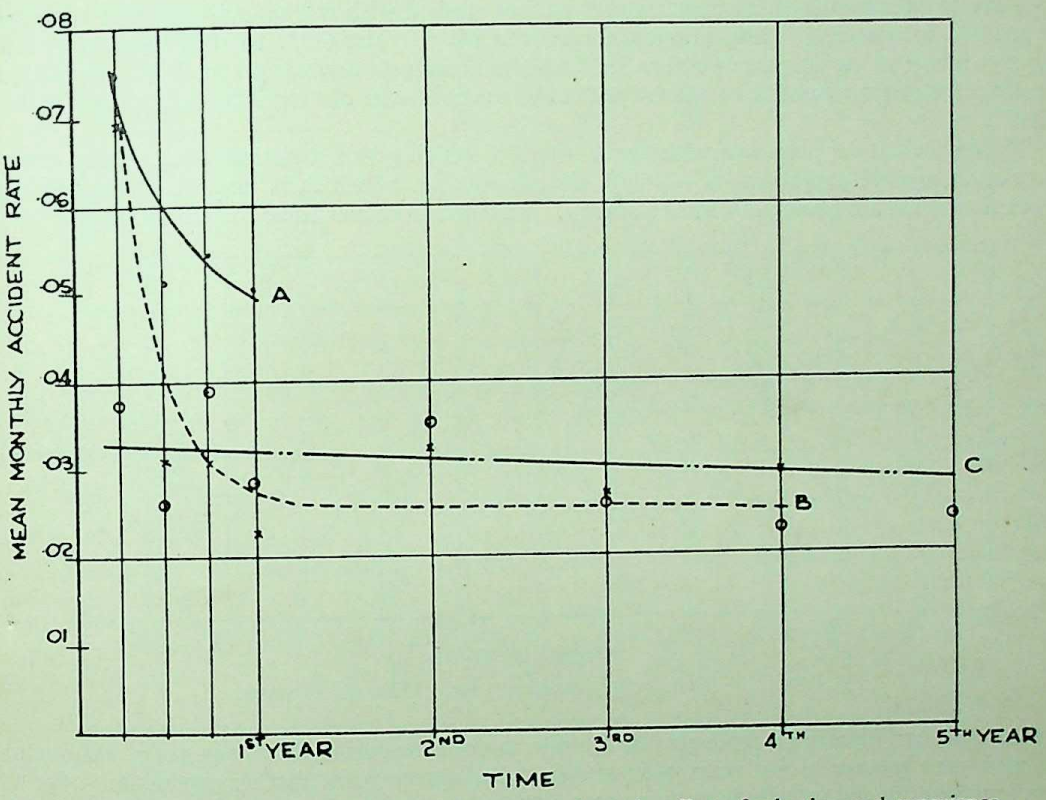

FIG. 9.—Accident rate of three groups of shunters to show the effect of selection and experience.

A. Men who began after January 1st, 1943, and left before 1948. 165–261 men.
B. Men who began after January 1st, 1943, and who did not leave before 1948. 182 men.
C. Men who began between 1937 and 1943 and who did not leave before 1948. 181 men.

year passes. Increasing experience or selection must be the cause of the diminishing rate. Section B shows a very rapid drop for the first quarter and then a slow decline. Here again age can hardly account for the early fall, and as there is no selection in this group experience seems to be the major factor in the initial fall of the rate. Section C has a very small tendency to decrease all the way, which can be accounted for by either experience or age, probably both together.

Now it is observed that the C section shows no initial steep "learning" process, and the question arises as to whether the difference between groups is confined chiefly to the early learning period, and that given time, the three groups would tend to settle closer to a common mean. Those men who influence the initial steepness may drop out. Of course it is only possible to guess what the subsequent history of the leavers would be. For practical purposes they constitute a group which influences the accident rate considerably. Furthermore the fact that there is a group of persons who leave work early militates against efficiency in industries in many ways besides the fact of

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their having accidents. Means of preventing this high labour turnover is a desirable goal in nearly all industries.

In order to hold experience constant, the accident rate is compared in three groups mentioned in connection with accident pronneess and shown in Tables 5, 6, 7 (p. 379). These tables show the accident distribution of men aged respectively 21–25, 26–30 and 31–36 years. The mean number of accidents of the groups are 0·7529, 0·5815 and 0·5806 respectively. The records are over the period of one year and the men have had no previous experience. The difference in the means of groups 21–25 and 26–30 is more than twice the standard deviation of the difference and can be taken to be significant, This would suggest that it is safer to start shunting after twenty-five than before twenty-five years of age.

A group of men whose accident records can be studied with reference to age and experience are the 122 men each of whom shunted for at least eleven years (1937 to 1947 inclusive). They began to shunt at varying times before 1937 and had reached varying ages at 1937. Hence their accidents for eleven years are correlated with two factors—years of experience before 1937 and age at 1937.

The coefficient for accidents with age is −0·137, which is not statistically significant, and the correlation against experience is −0·190, the significance of which is doubtful. Further facts about these men are shown in Figs. 10 and 11. The annual rate of these men is shown in Fig. 10,

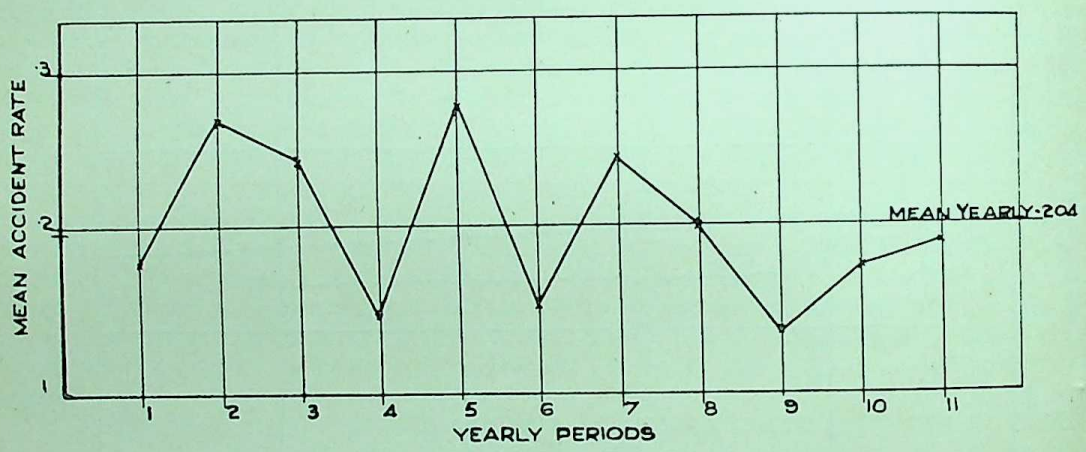

FIG. 10.—Mean yearly accident rate. 122 men, 11 years.

and here we can discern no tendency for the rate to decrease during the eleven years, although all the men have become eleven years older and have had eleven years' further experience. The 122 men are then divided into three groups according to the number of accidents sustained, i.e., those who had either nought or one accident, those who had two or three accidents, and those who sustained from four to eight accidents during the eleven years. The annual rate of each of these groups is shown in Fig. 11, and again we see that there is no significant tendency for the rate to diminish. These 122 men are a selected group in that they are stayers, but there is no way of overcoming this difficulty, and the longer the period observed the more highly selected the group becomes.

These findings seem to lead to the following conclusions:

(1) Both age and experience play a part in the initial year of work and then rapidly lose their effect, i.e., when beginners are examined the accident rate of the 21–25-year-old group is higher than that of the 26–30-year-old group, and in all groups of beginners the rate drops rapidly during the first year and then levels out.

(2) Both influences, that is age and experience, act with particular strength on the men who are destined to work for a short period.

(3) The shorter the period a group is destined to stay at work the higher its initial accident rate.

(4) After about two years of service the accident rate for all groups tends to become stabilized, and to remain so for at least eleven years.

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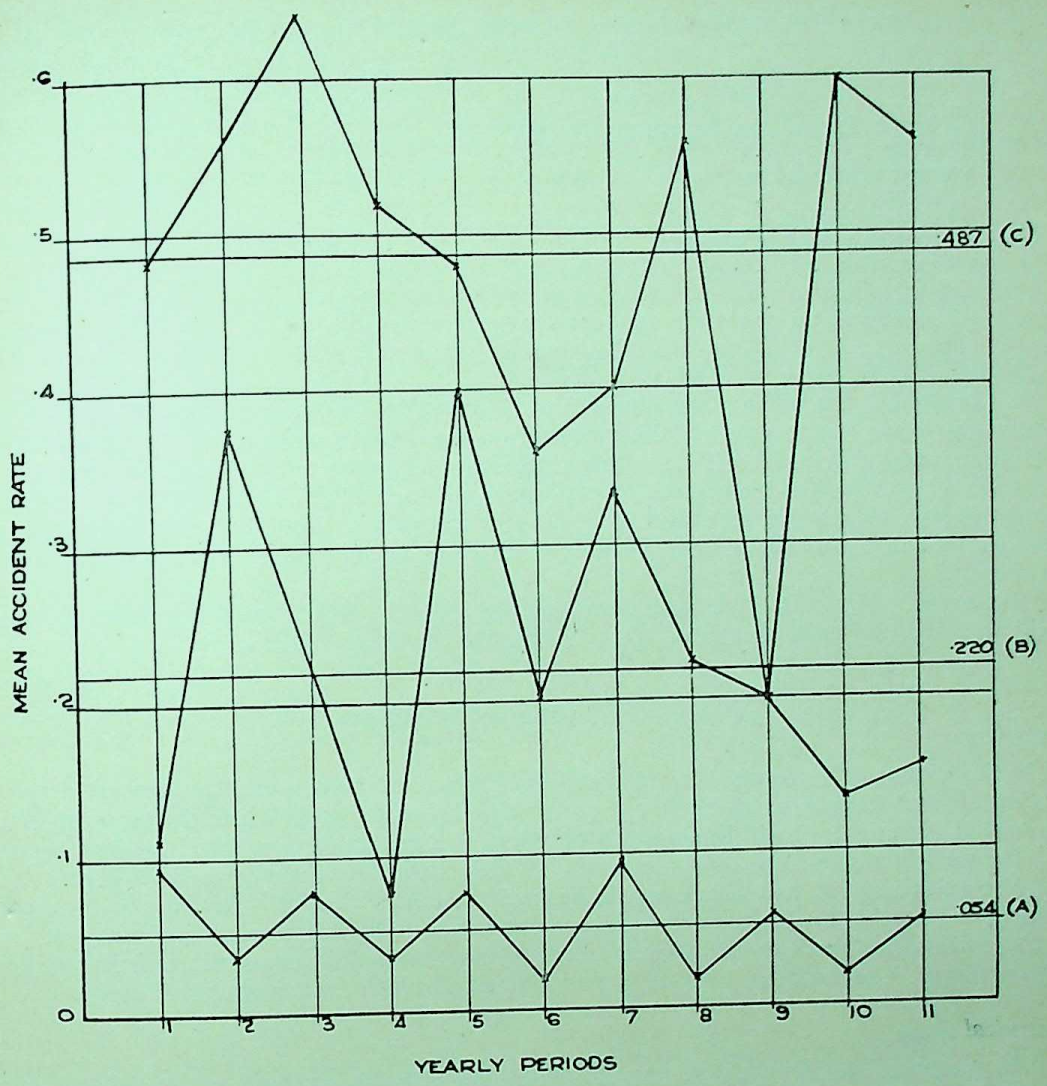

FIG. 11.—Mean yearly accident rate. Three groups; 11 years.

A. 0–1 Accident ; 52 Men.
B. 2–3 Accidents; 45 Men.
C. 4–8 Accidents; 25 Men.

IV. OTHER ACCIDENTS INCURRED BY SHUNTERS

Besides the data of shunting accidents which cause personal injury as described previously there are available certain facts about two other kinds of "accident", viz.,

(1) Injuries sustained at home.
(2) Accidents which cause damage to property.

(1) *Injuries sustained at Home*

From the records of sickness there have been extracted the details of injuries which cause absence from work for at least one day. The table below reflects the details of these home injuries for the 30 men who were present during the whole period 1943–1947.

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Nature of "Home" Injuries Sustained by 315 Men in Five Years

Nature of Injury	*Number of Cases*	*Days away from Duty*
Wounds, Lacerations, Bruises and Contusions	111	1,030
Sprains	31	274
Foreign Body in Eye	13	40
Fracture	10	221
Burns and Scalds	4	37
Shock as a result of Accident	2	10
Concussion	2	10
Total	173	1,622

(2) *Accidents which Cause Damage to Property*

In Chapter III the different aspects of the classification of accidents were discussed. An opportunity to investigate a part of this problem was presented at a depot which kept records of mishaps caused by shunters. These mishaps result in damage to property such as derailments, broken axle boxes, broken buffers, etc., but no injury to the shunter. This is an important factor in the industry, resulting in high costs from damage and delays. An inquiry is instituted in all cases and culpability is decided. All cases in which a shunter was found to be at fault are called "mishaps".

The figures relate to 157 men during the period 1946 to 1949. The data concerning these accidents are presented in greater detail in the Chapter on "Accident Proneness".

V(*a*). Accident Proneness (General)

Introduction

In this section it is proposed to trace the development of the concept "accident proneness", a concept which has played an important part in the theoretical approach to the personal factor in accident causation. It will be shown that the idea was developed from certain statistical work by Greenwood, Woods, Yule and Newbold. A recent paper on the subject by Kerrich (1950) will also be mentioned, and reference will be made to other statistical workers who have contributed to the subject. It will be pointed out that the term "accident proneness" was first used by the psychological workers Chambers and Farmer, using the conclusions of the statistical workers named above. The meaning of the term was widened and later became grossly misused.

Statistical Basis

The personal factor in accident causation was ignored by the engineer who labelled it carelessness.

In 1919 an entirely new approach was made and described by Greenwood and Woods in a report of the Industrial Fatigue Research Board. This report may be said to mark the beginning of the scientific investigation of the personal factor in accidents. The preface to the report states:

> ". . . it is desirable to ascertain whether accidents are distributed equally among the workers in the dangerous processes or are more or less limited to particular individuals . . .";

and further:

> "it (the report) affords strong ground for thinking that the bulk of the accidents occur to a limited number of individuals who have a special susceptibility to accidents, and suggests that the explanation of this susceptibility is to be found in the personality of the individual".

Greenwood and Woods introduced the problem concerning the analysis of the frequency distribution of accidents in an observed population by analogy to the experiment of throwing balls into pigeon-holes. They stated that when one knows the ultimate distribution of the balls in the pigeon-holes it is practicable to *form a judgment* as to the nature of the causes which operated

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in the distribution. They issued a warning about the *a priori* objections to the scheme as a proper representation of what occurs. Three hypotheses were enunciated, and examined in the cases of observed frequency distributions taken from certain factories. They were:

(1) That accidents occurred by pure chance;
(2) That persons were equal in their initial susceptibility to accidents, but that when a person incurred an accident, his chance of sustaining a second thereby became different;
(3) That persons were different in their liability to accidents from the start.

The authors described the methods for testing these hypotheses by fitting certain theoretical distributions to the observed distributions and they named the three methods "Simple Chance Distributions", "Biased Distribution" and "Distribution of Unequal Liabilities". For the "Simple Chance Scheme" the proportion of people who might be expected to have 0, 1, 2, etc. accidents in a period in which the mean number of accidents is λ is given by the terms of the Poisson limit to the binomial

$$e^{-\lambda}\left(1+\lambda+\frac{\lambda^2}{2!}+\frac{\lambda^3}{3!}+\ .\ .\ .\right).$$

For the "Biased Distribution" the authors found a solution in a complicated form difficult to apply, and used a simple approximation based on the assumption that the liability alters after the first accident only. For the third hypothesis they assumed for convenience that the individual susceptibilities were distributed in a simple curve of the form of Pearson's Type III. Each particular degree of liability results in a Poisson distribution. Hence the resulting probability function of accidents is a composite of Poisson distributions which can be determined by integration. This led to a simple distribution known as the negative binomial distribution in which the expected frequencies of 0, 1, 2, . . . accidents are given by the terms of the series

$$N\left(\frac{c}{c+1}\right)^r\left\{1+\frac{r}{c+1}+\frac{r(r+1)}{2!(c+1)^2}+\frac{r(r+1)(r+2)}{3!\,(c+1)^3}\ .\ .\ .\right\}$$

and r, c, are obtained from the statistics from

$$M=\frac{r}{c}$$

$$\mu_2=\frac{r(c+1)}{c^2},$$

where M is the mean and μ^2 the second moment about the mean of the distribution observed.

In the data examined by Greenwood and Woods it was apparent that the distribution calculated on the third hypothesis, i.e., the distribution of Unequal Liabilities, gave the best fit to the observed distributions.

Another method used by Greenwood and Woods was that of correlating the accidents of individuals in successive periods of time. They concluded:

> "Since there is considerable correlation between the records of successive periods, there can be little doubt that the Chance Distribution hypothesis is inappropriate".

The mathematical considerations underlying these theoretical distributions were set out in a paper published by Greenwood and Yule in 1920. Newbold made a contribution in 1926 when she continued the work of Greenwood and Woods on wider data.

In this contribution Newbold substantially verified the conclusions of Greenwood and Woods, and furthermore she widened this concept of "Unequal Liability" by introducing the added factor of the *consistence* of the individual tendency to accident under *different* circumstances. To do this she correlated two different types of accidents of individuals occurring in factories, and she also correlated home with factory accidents in the same individuals.

In 1927 Newbold summarized and generalized all the previous statistical work on the subject in a paper to the Royal Statistical Society. This, to date, is the most thorough analysis of the subject. In it Newbold considered a further aspect of the observed frequency distributions. If

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the frequency distribution was assumed to be a mixture of a large number of Poisson distributions each with its own mean (λ), Newbold showed how the parameters of the distribution of the λ's could be estimated.

It may be observed that any discontinuous distribution can be described mathematically as being built up of a mixture of Poisson distributions, even in cases when this is manifestly the wrong interpretation of the physical events to which we are applying the theory.

Recently Kerrich (1950) wrote a paper on Accident Proneness. He has approached the statistical analysis of the observed frequency distribution with a new orientation and without analogy to balls in pigeon-holes. He has reached fundamentally the same conclusions as those of Greenwood, Woods and Newbold.

He states:

> "If a . . . population is homogeneous it has a Poisson distribution over a finite interval of time of length T".

And further:

> "The converse of this statement *need* not be true, but if, as far as we could tell, an observed distribution is Poisson, we would be inclined to regard it as evidence suggesting that the population might be nearly equally accident prone if they had been working in the same environment. If, however, the population distribution is not a Poisson distribution, then the population cannot be homogeneous and we take this to indicate that individuals are not equally accident prone if they have been working in the same environment (this proviso is fundamental)".

A further point which Kerrich makes from his definition of homogeneity is: "If a population is homogeneous over the period $t_0 - t_2$ then $COV\ (x_0x_1) = 0$ and hence $r_{01} = 0$ where r_{01} is the coefficient of correlation between x_0 and x_1".

The converse, of course, need not be true.

Kerrich poses the question of the "degree of non-homogeneity", and states that it is tempting to regard r_{01} as some sort of measure, but he states that the question of how to interpret the correlation coefficient is a difficult one, and then describes Newbold's more direct method of investigating non-homogeneity. He states, "If the population consists of a mixture of homogeneous populations, we want to know how it is built up. We want to know the values of λ in the constituent populations and what proportion of the whole population each constituent is. This information is provided by its cumulative frequency distribution $F(\lambda)$ or by $dF(\lambda)$, and in theory complete knowledge of $F(\lambda)$ can be obtained from a knowledge of $p(x)$ . . . ", where x is the number of accidents. He then shows methods of estimating the first three of the four moments of $dF(\lambda)$. He states that this was explained by Newbold in 1927.

Kerrich mentions the attempt of Minz and Blum (1949) to obtain a "*single*" measure of the differences in accident liability within the population, viz., by estimating $\frac{100\mu_2(\lambda)}{\mu_2(x)}$. This gives the percentage of total variance which can be attributed to the presence of differences in accident liability. He says:

> "But in principle we wish to criticize severely all attempts to describe a complicated situation by means of a *single* measure. Surely, the common-sense point of view is to try to obtain *all* the information we can . . . ".

Ending this article Kerrich repeats the warning that the theory is based on the "bold assumption" that we are dealing with a mixture of Poisson populations, saying:

> "But this is no *proof* that our particular $p(x)$ was built up in this manner. It might happen that $p(x)$ was built up in such a manner that it would be arrant nonsense to apply the type of analysis discussed here".

Other authors have also written about this point. Irwin (1941) and Anscombe (1949) have shown various ways in which a negative binomial distribution could arise. Greenwood (1949) states:

> "A negative binomial could arise in a great many ways, and if one had a negative binomial and it was a good fit, accident proneness might be involved or it might not".

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Certain other facts about the mathematical models involved in the determination of accident proneness were shown by Maritz (1950), who points out that in theory it is possible for $p_0(x_0)$ and $p_1(x_1)$ to be non-Poisson and yet for r_{01} to be zero. He gives an example also of a case where $p_0(x_0)$, $p_1(x_1)$ are Poisson distributions, but r_{01} is non-zero and $p(x_1 + x_2)$ is non-Poisson but is a good fit to the negative binomial distribution.

Kerrich, commenting on the first case, says "should this occur in practice, the fact that $p_0(x_0)$ and $p_1(x_1)$ and hence, in general $p(Z) = p(x_0 + x_1)$ are non-Poisson would be evidence that the population was not homogeneous over the whole interval $t_0 - t_2$ even if it so happened that for two *particular* sub-intervals $r_{01} = 0$".

Maritz' second case is taken from the data concerning shunters in this report, and discussed in the next section. Our conclusion about this group is similar to that made by Kerrich, viz., that this could be a case where the group is so nearly homogeneous that it must be observed for a considerable time before definite statistical evidence of non-homogeneity can be observed.

A point made by Kerrich which should be emphasized is that in general natural phenomenon are "infinitely variable", and hence concepts such as absolutely homogeneous populations are concepts only and never do occur. Hence we are never likely to "prove rigorously" that a group of individuals is homogeneous. It is very unlikely that for all possible subintervals of time the correlation would be zero.

In order to compare the distribution of different sets of data Smeed (1949), Greenwood (1950) and Kerrich (1950) have shown a method which scales the distribution by making the mean value of λ equal to unity. Greenwood said that the process was akin to "standardization" of death-rates, and hence the term "standardized accident liability" will be used.

Another distribution which has been fitted to accident data is the Neyman Type A curve. This was described by Neyman (1939) when dealing with infection among larvae and is an example of a contagious distribution. Feller (1944) has shown that this distribution can also be derived by a similar process to that used in deriving the negative binomial but in this case the λ are taken to be distributed with a Poisson law, i.e., a series of Poisson distributions whose means (λ's) are distributed in a Poisson curve. (We have used this distribution in connection with the sickness data in Chapter VIII.)

When using the statistical methods mentioned above, it is of course obvious that the factors which are known to influence accidents are taken into consideration before the distributions are examined, e.g., exposure to risk should be equal for all members of the population, as should age, experience, health, etc. Each of these variables raises problems, which have been dealt with in separate sections of the thesis.

A technique which is related to the concept of accident proneness is that described by Archibald and Witfield (1947). The method does not require equal exposure to the accident hazard, and is described in detail in the next section when it is applied to the data of shunters' accidents. The method is designed to estimate the number of pairs of accidents of the same type which are expected to occur and to compare the estimated numbers with those observed.

Psychological Approach

The first mention of the term "accident proneness" was made in 1926 by Farmer and Chambers (1926). After mentioning the statistical work of Greenwood, Woods, and Newbold they stated: "various psycho-physical tests have been given to groups of factory workers and it has been found that those who did well in certain of them tended to have fewer accidents than those who did badly". And further:

> "The fact that one of the factors connected with accident liability has been found to be a peculiarity of the individual allows us to differentiate between 'accident proneness' and 'accident liability'. 'Accident proneness' is a narrower term than 'accident liability', and means a personal idiosyncrasy predisposing the individual who possesses it in a marked degree to a relatively high accident rate. 'Accident liability' includes all the factors determining accident rate: 'accident proneness' refers only to those that are personal. We do not know yet whether 'accident proneness' is a general or a specific factor.
>
> " 'Accident proneness' implies the possession of those qualities which have been found from independent research to lead to an undue number of accidents".

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In 1941 Chambers (1941) wrote:

> "Summarizing briefly, what is now known about 'accident proneness', we may say that it is relatively stable, in the sense that persons with a larger number of accidents than their fellows in one observational period tend to have more accidents in subsequent periods, and also that persons tending to sustain a number of one kind of accident tend also to sustain a number of other types".

Earlier Farmer and Chambers (1939) stated:

> "Accident Proneness is no longer a theory but an established fact, and must be recognised as an important element".

It is evident that in the use of the term "accident proneness" by Farmer and Chambers, there are several different implications, viz.:

(1) That under equal conditions certain individuals are likely to sustain more accidents than others.
(2) That the operation of this quality can be measured, and the difference between the number of accidents can be prognosticated by means of psychophysical tests.
(3) That the quality is stable.
(4) That persons prone to one kind of accident tend to be prone to other kinds.

Farmer and Chambers based their ideas on the statistical work of Greenwood, Woods, Newbold and Yule. Greenwood and Woods had shown that "unequal liabilities" existed. Newbold suggested that these "unequal liabilities" were consistent under different circumstances. Now Farmer and Chambers in taking the further step of separating "accident proneness" as a special factor within "accident liability" made an abstraction for which there was not complete justification.

Some reasons for this criticism of Farmer and Chambers have been dealt with in Chapter III when problems of classification were discussed. Although the statistical methods involved were sound, the data from which Newbold, and Greenwood and Woods drew their conclusions suffered from serious defects of a classificatory nature. Trivial accidents were being dealt with, and they were extremely likely to have been measuring the "tendency to report" rather than the "tendency to have" accidents. The data of home and work accidents used by Newbold were of a very doubtful nature, with the "tendency to report" playing an important part in the correlation. No evidence more adequate than that of Newbold has been presented to show that persons prone to one kind of accident are also prone to other kinds. When proneness has been shown it is proneness confined to a particular environment.

Nevertheless when once the announcement of the "accident proneness" discovery was made it was seized upon as the open sesame to all accident problems, and a host of workers in this field began to use the idea without reference to the original work. The idea readily lent itself to a dichotomy—this man is accident prone—this man is not. What gave impetus to this development was that from the findings of the above authors it followed that ". . . in almost all the groups the average number of accidents is much influenced by a comparatively small number of workers" (Newbold, 1926). Now this began to be taken as the criterion on which to base the proof of the existence of accident proneness, so that if, say, 19 per cent. of the men were responsible for say 46 per cent. of the accidents, it was accepted that accident proneness was the cause. The incorrect assumption was made that if chance factors only were acting all persons in the population should have the same number of accidents. Of course this need not be true, because in random distributions it will be found that a small proportion of men will cause a larger proportion of accidents, and, using their argument, the height of absurdity would be reached when there were fewer accidents than men, in which case 100 per cent. of accidents would *have* to be caused by less than 100 per cent. of men.

Alexander Mintz and Milton L. Blum (1949) point out that such a line of reasoning was used in some well-known American studies, e.g., those of the National Association of Taxicab Owners and the Metropolitan Life Insurance Company. They point out that Viteles in his well-known text-book failed to compare the data with a chance distribution, and that in a similar way Slocombe and Brakeman in their study of accident proneness used this naïve line of argument.

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In her book, *Psychosomatic Diagnosis*, Flanders Dunbar (1943) places emphasis on accident proneness ; in fact she bases a large part of the book on this concept and she quotes examples to prove it; but they are almost all of the above type of argument, e.g., on p. 174 appears the following: "Heinrich's report gives less than ·8 per cent. of the employees as responsible for 10 per cent. of the accidents."

Dunbar would seem to want to put all the possible generalizations into the concept and thus on p. 170 we find the following statements:

> "The people who have the worst accident record while at work also have the highest record for accidents at home or elsewhere."
>
> "It has been found that the people who have accidents are also the people who make mistakes, the kind of mistakes that sink a ship, lose a battle or explode a munition plant."
>
> "Since accidents and mistakes which endanger the lives of others go hand in hand . . . ."
>
> "These studies suggest that the accident-prone person can be spotted rather easily. Actually he can be spotted with less expense than the person with tuberculosis or heart disease, for whom the expense of roentgenograms is *often* required."

Dunbar's own contribution to the subject is based upon the fact that when investigating the psychological background of hospital patients with fractures it was found that they had characteristics which were different from those found among patients suffering from other diseases such as heart disease, rheumatic disease and diabetes. Among these characteristics was their history of previous accidents, which was much higher than that of the other patients.

There can be no doubt that selection must have played a part in determining Dunbar's fracture group because the fracture patients would be more likely to be drawn from persons who are more exposed to accidents. Hence one would expect this group to have a history of more previous accidents. Furthermore the patients in the fracture wards might be more likely to think about and remember previous accidents than patients with, say, heart disease, who might think such a previous event to be unimportant in their lives. Furthermore the classification of accidents in the history-taking was vague. The method of analysis of accident data used by Dunbar cannot be taken to indicate accident proneness. It certainly gives no justification for the wide generalization with which she introduces her study.

Other investigations of a similar character have been published. Tillmann and Hobbs (1949) in a study on taxi drivers found that differences in personality and character play a greater part than pure driving skill in determining the number of accidents. The work suffers from weaknesses in that it does not describe the population at risk but only the observed extremes, and the testing was done after knowing what group was being dealt with.

Wong and Hobbs (1949) published an investigation on a factory group. They accepted the whole "accident-prone" concept as set out by Dunbar, and then proceeded to examine a small sample of men who had most accidents in a factory. They obtained results which suggested that the "prone" persons had certain characteristic social backgrounds and modes of behaviour which the "non-prone" persons did not have, and that these were similar to the characteristics noted by Dunbar. However, their small sample (fourteen men) and the fact that they did the testing after knowing that the group had a higher accident record makes the work unsatisfactory.

A publication by Adler (1941) in which men with high accident rates are psychologically examined suffers from similar drawbacks. An investigation on similar lines but which was much more thoroughly and scientifically carried out was published by Biesheuvel and White (1949). Pupil pilots were aptitude-tested *prior* to their starting flying-training. Information on their intelligence, skill and personality make-up was therefore available. Subsequent to the training period an accident group was selected consisting of two hundred pilots who had been involved in flying accidents, and the records were compared with four hundred men who had an accident-free record. Differences were found which were sufficient to suggest methods of selection of those who were not likely to have accidents.

Comment

The development of the concept of accident proneness has been traced. Certain statisticians, given data of accident distributions, developed methods of showing "unequal liabilities" among

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the population concerned. The psychological workers made an abstraction which they called "accident proneness", and which was a part of accident liability. Later they concluded that accident proneness, a quality connected with personality, operated in all circumstances. The warnings of the original statistical workers about definition of the thing measured were ignored and accident proneness came to take on several unsubstantiated meanings.

We feel, nevertheless, that there is a great value in the methods developed by the statistical workers, and that the concept of accident proneness is extremely useful if it is not stretched beyond the observed facts. The hypothesis that proneness is a phenomenon which operates as a "general' factor in all circumstances has yet to be proved. The terms "unequal liability" of Greenwood and Woods and "non-homogeneous population" of Kerrich seem to be adequate descriptions of the mathematical models which these authors evolved, but the concept must operate for a population within a specific environment and for a specific type of occurrence, unless and until further facts can be established.

V(*b*) Accident Proneness in Shunters

The records of shunters are analysed by:

(1) Fitting Poisson and negative binomial distributions to the observed distributions, and estimating the "true accident liability".
(2) Finding coefficients of correlation between accidents sustained by each individual during two consecutive periods.
(3) Examining the correlation between accidents at work and accidents at home in the same individuals.
(4) Finding the correlation between major and minor accidents.
(5) Examining the correlation between accidents causing injury and accidents causing damage to property.
(6) Examining the accidents which cause damage to property, with techniques similar to those mentioned above.
(7) Comparing the "standardized accident liabilities".
(8) Finding the correlation between accidents and the number of sicknesses experienced.
(9) Testing the effect of removing the men with highest accident rate.
(10) Estimating the probability of the repetition of similar accidents.

(1) *and* (2). *Fitting Poisson and Negative Binomial Distributions and Finding Coefficients of Correlation*

This procedure was followed in respect of five groups:

(*a*) The first year of shunting. A group of men with no previous experience divided into age-groups 20–25, 26–30, 31–35 years.
(*b*) One hundred and eighty-two men who shunted during the whole five-year period, 1943–1947, and whose experience varied between nought and five years.
(*c*) One hundred and twenty-two men who shunted during the whole eleven-year period, 1937–1947, in respect of both shunting accidents and—
(*d*) Home accidents.
(*e*) Later, under procedure (6), a fifth group, i.e., one hundred and fifty-seven with records of mishaps causing damage to property is also examined in this way.

(*a*) *First year of shunting.*—In order to hold experience constant and to test the distribution at the beginning of their careers a group of shunters was examined in their first year of experience. Each individual was followed for one year some time during 1943–1947, and it is not the same year for each person. The group comprises all shunters who had their first year of shunting during the period 1943–1947. No selection was made. In order to eliminate the effects of age as far as possible, the men were divided into three age-groups, 21–25 years, 26–30 years, and 31–35 years. Each distribution was compared with a Poisson. Negative binomial distributions were not fitted because, in these cases, the variances are larger than the means. The findings are shown in Tables 5, 6 and 7.

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TABLE 5

Comparison of Observed with Expected Distributions. First Year of Shunting. Age 21–25 Years

Number of Accidents	*Number of Men*	
	Observed	*Poisson*
0	80	80·4
1	56	60·1
2	30	22·6
3	4	6·9
Total . .	170	$\chi^2 = 3{\cdot}89$
Mean . .	·7529	$P = {\cdot}151$

TABLE 6

First Year of Shunting. Age 26–30 Years

Number of Accidents	*Number of Men*	
	Observed	*Poisson*
0	121	127·2
1	85	73·6
2	19	21·4
3	1	4·8
4	0	
5	0	
6	1	
Total . .	227	$\chi^2 = 3{\cdot}17$
Mean . .	·5815	$P = {\cdot}079$

TABLE 7

First Year of Shunting. Age 31–35 Years

Number of Accidents	*Number of Men*	
	Observed	*Poisson*
0	80	86·9
1	61	50·2
2	13	14·6
3	1	3·3
Total . .	155	$\chi^2 = 3{\cdot}716$
Mean . .	·5806	$P = {\cdot}055$

The results show that these distributions could be explained by the Poisson, i.e., chance distribution.

(*b*) The next group examined were the 182 men who shunted for at least the five years 1943 to 1947, and who began to shunt at any time from 1937 to 1942. The experience of these men before 1937 was therefore variable and ranges from nil to five years. Their ages also varied considerably. The effect of experience on this group is shown in Fig. 9 and it can be seen that except for the first quarter the annual accident rate is very stable. The findings are shown in Table 8. Here both the Poisson and negative binomial distributions are good fits, the negative binomial being slightly better ($P = {\cdot}396$ and ·574 respectively).

In Table 9 is shown the correlation table when the accidents are divided into two periods of thirty months each. The correlation coefficient is ·138 and is not significant. Because of this coefficient and the fit of the Poisson distribution it is doubtful whether or not unequal liability is manifested to any great extent in this group. The good fit of the negative binomial might suggest positive evidence. In accordance with the method mentioned for estimating the true accident liabilities (i.e., the distribution of λ), Fig. 12 shows the cumulative frequency distribution of this factor and also the cumulative distribution of the fitted negative binomial.

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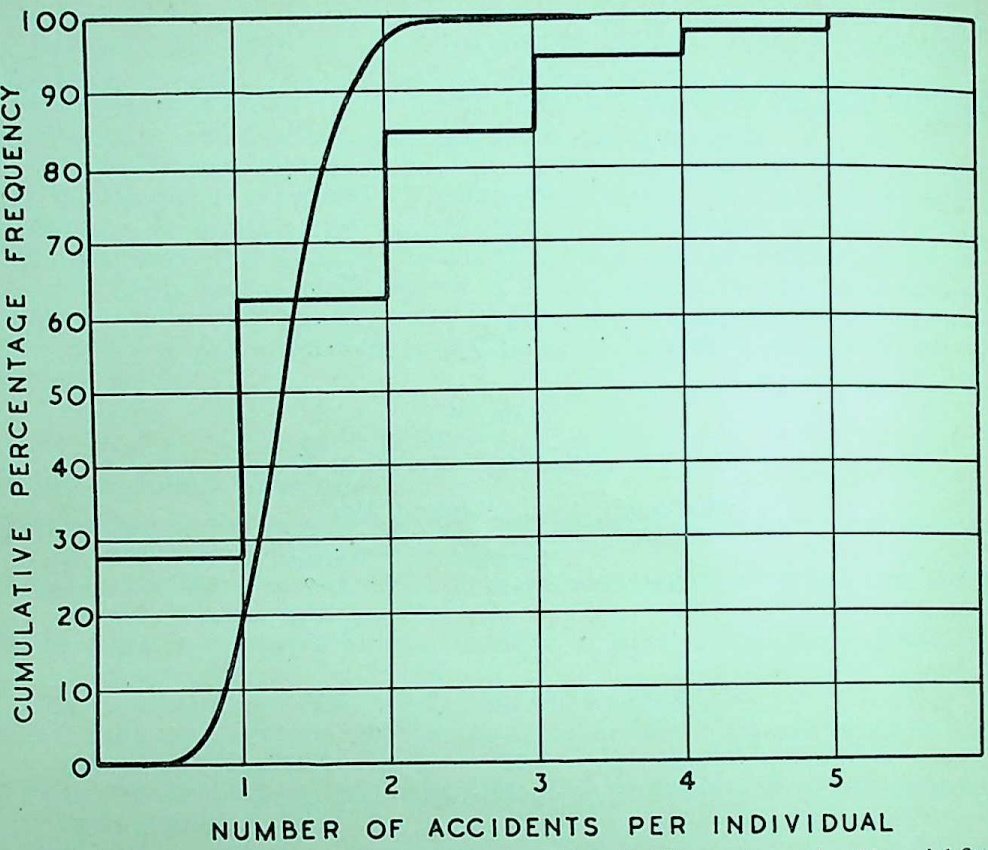

FIG. 12.—Estimated cumulative distributions of true accident liability and negative binomial fitted to observed distributions of accidents. 182 shunters; industrial injuries; 5 years.

TABLE 8

Comparison of Observed with Theoretical Distributions of Accidents (Injuries) of 182 *men who shunted for* 5 *years*, 1943–1947, *and who had* 0–5 *Years Previous Experience*

Number of Accidents	*Number of Men*		
		Calculated	
	Observed	*Poisson*	*Neg. Binomial*
0	54	48·65	51·47
1	60	64·15	62·17
2	36	42·32	40·14
3	21	18·60	18·39
4	10	6·15	6·71
5	1	2·13	3·12
6	—		
Total . .	182	$\chi^2 = 3·03$	$\chi^2 = 1·13$
		$P < ·396$	$P < ·574$

TABLE 9

Correlation of Accidents of 182 *Men in Table* 8, *during Two Thirty-month Periods*

Accidents 2nd 30 Months	*Accidents 1st 30 Months*			
	0	1	2	3
0	54	34	13	1
1	26	15	9	4
2	8	10	5	1
3	1	1	—	—

$r = ·138$

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(*c*) The third group of men to be examined were the 122 men who shunted during the eleven-year period from 1937 to 1947. Their previous experience varied from nought to twenty-five years. The accidents of this group were discussed in Chapter IV in relation to age and experience, and it was shown that there is no evidence that age or experience influences the rate during the period under observation. Table 10A shows the distribution of accidents during the first six years

TABLE 10A, B, C

Comparison of Observed with Theoretical Distributions. Accidents of 122 *Men over* 11 *Years,* 1937–1947, *Reflecting—*

A. *First six years*, 1937–1942
B. *Next five years*, 1943–1947
C. *Total eleven years*, 1937–1947

A. *Six Years*, 1937–1942

Number of Accidents	*Number of Men*		
	Observed	*Calculated*	
		Poisson	*Neg. Binomial*
0	40	34·29	40·05
1	39	43·48	39·36
2	26	27·27	23·79
3	8	11·69	11·38
4	6	5·27	4·72
5	2		2·74
6	1		
Total . .	122	$\chi^2 = 5·27$	$\chi^2 = 1·54$
		$P = ·161$	$P = ·468$

B. *Five Years*, 1943–1947

Number of Accidents	*Number of Men*		
	Observed	*Calculated*	
		Poisson	*Neg. Binomial*
0	50	45·8	52·36
1	43	44·8	38·69
2	17	21·9	18·98
3	9	9·5	7·73
4	2		4·23
5	0		
6	0		
7	1		
Total . .	122	$\chi^2 = 2·19$	$\chi^2 = ·97$
		$P = ·341$	$P = ·336$

C. *Eleven Years*, 1937–1947

Number of Accidents	*Number of Men*		
	Observed	*Calculated*	
		Poisson	*Neg. Binomial*
0	21	12·9	21·5
1	31	29·0	29·5
2	26	32·6	25·9
3	19	24·4	18·6
4	7	13·7	11·8
5	9	6·1	6·9
6	5	3·3	7·8
7	1		
8	3		
Total . .	122	$\chi^2 = 18·9$	$\chi^2 = 2·873$
		$P < ·001$	$P = ·582$

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and Table 10B during the next five years. In both these cases the Poisson distributions give significant fits with P values equal to ·161 and ·341, while the negative binomial probabilities are ·468 and ·336. Table 10C shows the distribution of these men for the whole eleven years, and now the picture has changed. The Poisson fit gives a probability of less than ·001, while the negative binomial probability is ·382.

The correlation tables for accidents occurring to these 122 men during various periods of the eleven years are shown in Tables 11A, B, C, D. Tables 11A is for the first six years against the next five. The coefficient of correlation is ·258 and is significant. For the next three correlations the eleven-year period has been divided into four approximate quarters: three years, three years, thirty months and thirty months consecutively. The correlations shown in Tables 11B, C, D are

TABLE 11A, B, C, D

Correlation Tables for 122 *Men who Shunted for* 11 *Years*, 1937–1947. *Showing Accidents* (*Indust.*) *during Various Periods*

A. *Six Years against Five Years.*
B. *First Three Years against Next Three Years*
C. *Second Three Years against Next Thirty Months*
D. *Third Quarter* (*Thirty Months*) *against Fourth Quarter* (*Thirty Months*)

A. *Accidents* 1937 *to* 1947 *against Accidents* 1943 *to* 1947

Number of Accidents 1945–1947	*Number of Accidents* 1937–1942						
	0	1	2	3	4	5	6
0	21	18	8	2	1	–	–
1	13	14	10	1	4	1	–
2	4	5	4	2	1	0	1
3	2	1	3	2	0	1	0
4	0	1	1	–	–	–	–
5	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–
7	–	1	–	–	–	–	–

$r = ·258$

B. *Accidents in First Quarter against Accidents in Second Quarter*

Accidents in Second Quarter	*Accidents in First Quarter*				
	0	1	2	3	4
0	40	23	7	2	–
1	17	12	3	2	–
2	6	2	4	1	1
3	1	–	–	–	–
4	–	–	–	–	–
5	1	–	–	–	–

$r = ·109$

C. *Accidents in Second Quarter against Accidents in Third Quarter*

Accidents in Third Quarter	*Accidents in Second Quarter*					
	0	1	2	3	4	5
0	43	18	6	1	–	–
1	20	13	6	–	–	1
2	7	2	2	–	–	–
3	1	2	–	–	–	–

$r = ·0482$

D. *Accidents in Third Quarter against Accidents in Fourth Quarter*

Accidents in Fourth Quarter	*Accidents in Third Quarter*			
	0	1	2	3
0	50	24	5	1
1	19	9	2	1
2	3	5	–	–
3	1	1	–	–
4	–	–	–	–
5	–	–	1	–

$r = ·20$

the first quarter against the second, the second against the third and the third against the fourth quarter. The coefficients of correlation are ·109, ·048, ·205, only the third being statistically significant.

The fact that there can be a positive correlation between accidents in two successive periods whilst the "marginal" distributions are of the Poisson type has been commented on by Maritz (1950) using the figures in Table 11A as an example. Because of the clearly non-Poisson distribution of the eleven-year period and the significant correlation coefficient when the accidents of the first six years are correlated with those of the next five, we conclude that we are dealing with a distribution of Unequal Liabilities, i.e., that accident proneness is a factor in this data. Now we wish to estimate the distribution of the underlying "true accident liabilities", i.e., the distribution of the λ's.

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The estimated "accident liability" is shown graphically in Fig. 13 as a cumulative distribution, as is also the cumulative distribution of the fitted negative binomial. Fig. 13 shows that there is quite a wide scale of difference in the "accident liabilities" of these shunters. This of course assumes that the underlying theory of the composition of the liabilities is correct. It must be pointed out that the function k which is used for this estimate has a wide variance, and therefore our estimate is very unreliable. It is the *observed* estimate which has been graphed.

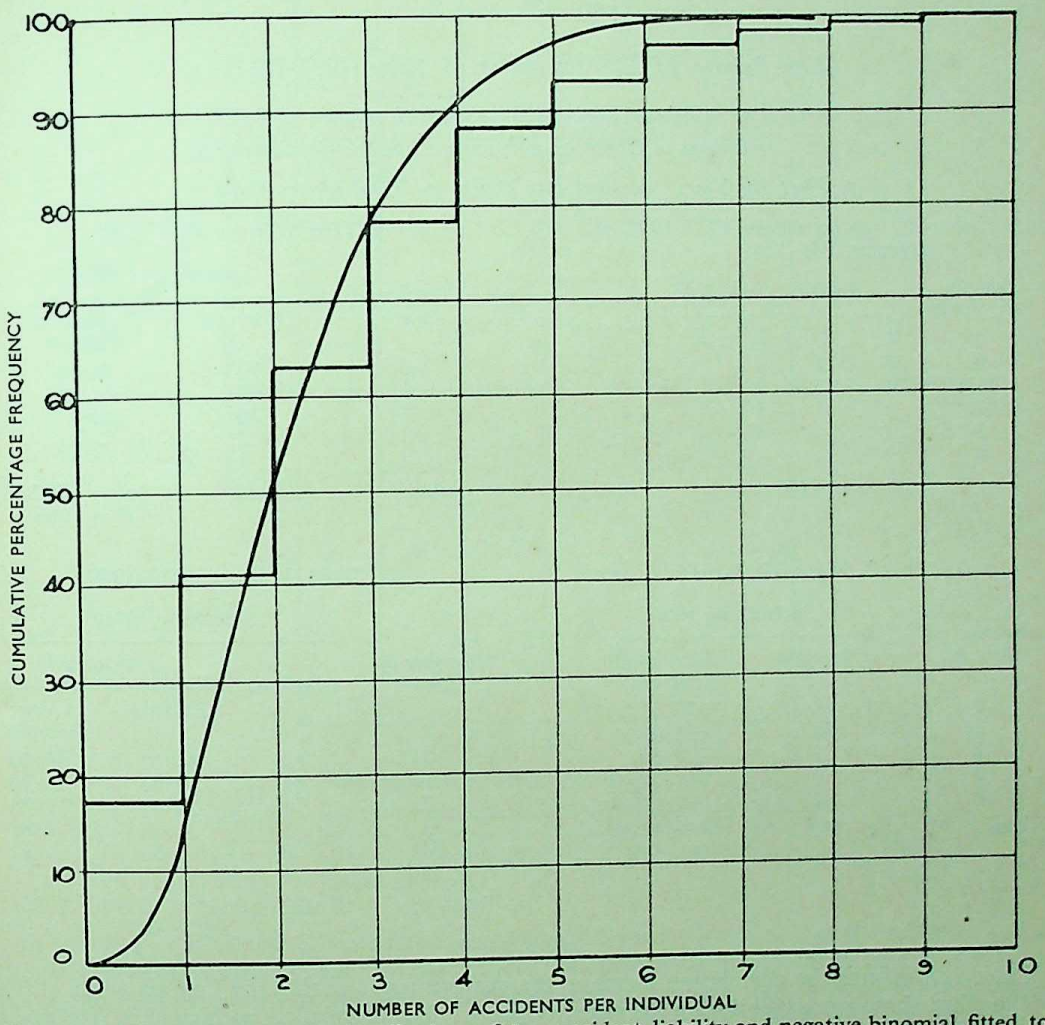

FIG. 13.—Estimated cumulative distributions of true accident liability and negative binomial fitted to observed distributions of accidents. 122 shunters; industrial injuries; 11 years.

The groups examined in this section reveal that unequal liabilities to injury, as we have defined it, appear only after eleven years have passed. In the group of 122 men who have shunted for eleven years, the correlation of accidents occurring in the first six years with those in the next five is positive and significant, and the distribution for the eleven years is of the negative binomial type. Hence we conclude that individual liabilities in this group differ "quite a lot", but this is so masked by "chance" events that it takes many years before we get a fairly reliable measure of how much they differ. These accidents which occur as a result of liability common and relatively equal in all the men are sufficiently numerous to mask the correlation due to those accidents which occur as a result of differing individual liabilities, i.e., until eleven years have passed when the differing degrees of proneness show statistically. The critical question is whether this factor is

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practically significant. The answer suggested is that it is not, but this question will be further discussed after more facts concerning these accidents are presented.

(*d*) The 122 men whose records of industrial injuries have been examined also had records of injuries sustained at home, i.e., away from work. These injuries have been described in Chapter V, and they are now to be examined in the same way as the industrial injuries. The results are shown in Tables 12A, B, C, D.

TABLE 12A, B, C, D

Home Injuries of 122 *Men during* 11 *Years* (1937–1947)

A. *Correlation of Injuries during* 1937–1942 *with Injuries* 1943–1947

B, C, D. *Comparison of Observed with Theoretical Distribution during*

B. *First Six Years* C. *Next Five Years* D. *Total Eleven Years*

A. *Correlation of Injuries during* 1937–1942 *w Injuries* 1943–1947

Injuries 1937–1942	*Injuries* 1943–1947				
	0	1	2	3	4
0	58	11	3	2	1
1	23	6	4	1	–
2	5	1	3	1	–
3	1	–	1	–	–
4	1	–	–	–	–

$r = \cdot 168$

B. *First* 6 *Years*, 1937–1942.

Number of Injuries	*Number of Men*	
	Observed	*Calculated Poisson*
0	73	71·18
1	36	38·26
2	10	10·37
3	2	2·19
4	1	
Total . .	122	$\chi^2 = \cdot 202$ $P = \cdot 664$

C. *Next* 5 *Years*, 1943–1947

Number of Injuries	*Number of Men*	
	Observed	*Calculated Poisson*
0	88	77·11
1	18	35·28
2	11	8·16
3	4	1·45
4	1	
Total . .	122	$\chi^2 = 14 \cdot 24$ $P < \cdot 01$

D. *Total* 11 *Years*, 1937–1947

Number of Injuries	*Number of Men*		
	Observed	*Calculated*	
		Poisson	*Neg. Binomial*
0	58	45·82	56·20
1	34	44·83	34·92
2	14	21·97	17·28
3	8	9·38	7·82
4	6		5·78
5	2		
Total . .	122	$\chi^2 = 13 \cdot 48$ $P < \cdot 01$	1·564 $P = \cdot 465$

Table 12A reflects the correlation between injuries sustained during the first six years (1937–1942) against those sustained during the next five years. The correlation coefficient is ·168 and is not significant.

Tables 12B, C, D reflect the observed distributions compared with the calculated distributions during the first six years, the next five years, and the whole eleven-year period. It is observed that the Poisson distribution gives a good fit, with $P = \cdot 664$ for the first six-year period, but the fit must be rejected for the next five-year period ($P < \cdot 01$), and for the eleven-year period ($P < \cdot 01$). For the eleven-year period the negative binomial distribution is a good fit ($P = \cdot 465$).

Fig. 14 reflects the cumulative distribution of the fitted negative binomial for the eleven-year period, and also the cumulative distribution of the estimated "true accident liabilty". In this case also it is observed that the spread of liabilities is quite considerable.

Maritz (1950) has pointed out that it is possible in theory for the marginal distributions to be non-Poisson and correlation coefficient to be zero. This is a case resembling Maritz' theory in that one marginal distribution is non-Poisson. Kerrich (1950) comments on Maritz' case by saying "the fact that $P_0(x_0)$ and $P_1(x_1)$ (and hence $P(Z) = P(x_0 + x_1)$ are non-Poisson would be

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evidence that the population was not homogeneous over the whole interval $t_0 - t_2$, even if it so happened that for two *particular* subintervals $r_{01} = 0$".

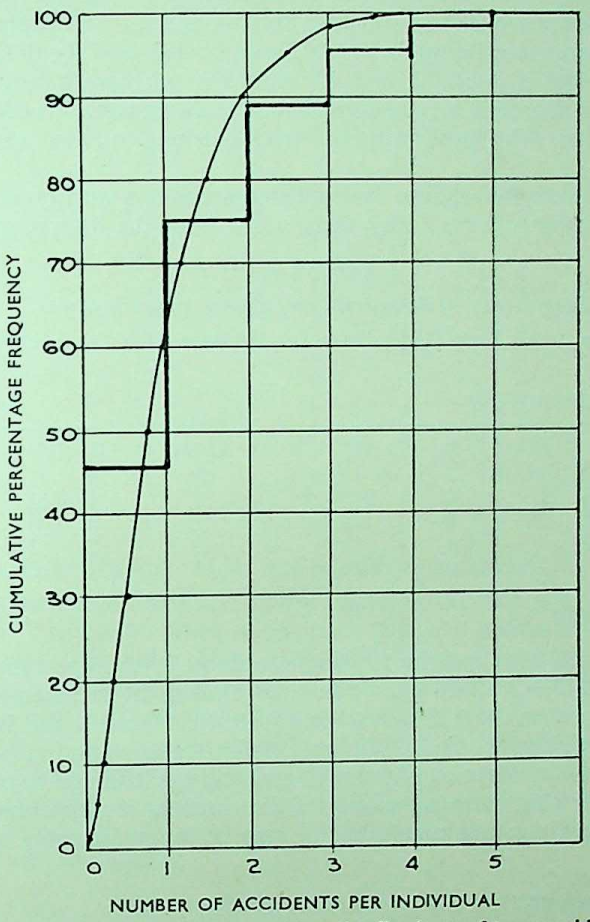

FIG. 14.—Estimated cumulative distributions of true accident liability and negative binomial fitted to observed distributions of accidents. 122 shunters; home injuries; 11 years.

In agreeing with Kerrich it is concluded that there is evidence of accident proneness in this group in respect of home accidents, but that the tendency is masked by chance events to a greater extent than in the case of industrial injuries. Possibly this is so because there are fewer home injuries than industrial injuries.

A factor which may be of importance in considering these data is the process of self-selection which was mentioned in connection with age and experience. The groups which have been examined are those who stayed on the job for the observed period, e.g., one, five, or eleven years. The obvious question is, did those who left the job leave because they were accident prone? Did they perhaps feel anxious when they were at work? The accident rate of these men is known to be higher than that of the men who stayed, but there is no way of knowing what their subsequent history would have been. The problem cannot be solved from the available information. Possibly personal interviews with the men might uncover some motives for leaving.

(3) *Correlation between Home and Industrial Accidents in the Same Workers*

The only possible doubt about the figures for home injuries is that there may be a tendency to be absent for trivial reasons, but as most of the accidents examined tend to be of a fairly serious

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nature this factor is probably negligible. If there is any "tendency to be absent" one would expect that the same men would use both opportunities, i.e., home injuries and industrial injuries, and hence increase the correlation between the two factors. The two groups mentioned above were examined, 122 men for eleven years and 181 men for five years. The figures are given in Tables 13A and 13B. The correlation coefficient for the 122 men is ·187, and for the 181 men it is −·029. The significance of the first is doubtful, and the second is not significantly different from zero. The size of the first correlation is in any case small, and hence we conclude that there is no evidence to suggest that the shunters who have most industrial injuries also have most injuries when away from work.

Newbold (1926) has published figures for similar correlations with home and work accidents taken from ambulance-room reports. Her facts suffer from the defects mentioned previously,

TABLE 13A, B

Correlation of Industrial and Home Injuries for—

A. 122 *Men for* 11 *Years* (1937–1947) B. 181 *Men for* 5 *Years* (1943–1947)

A

Injuries at Home	*Injuries at Work* 0	1	2	3	4	5	6	7	8
0	12	15	12	10	1	6	2	–	–
1	7	8	7	6	2	2	0	1	1
2	1	5	1	2	3	–	2	–	–
3	–	2	3	1	–	–	1	–	1
4	1	1	2	–	–	1	–	–	1
5	–	–	1	–	1	–	–	–	–

$r = \cdot 1867$

B

Injuries at Home	*Injuries at Work* 0	1	2	3	4	5
0	38	31	23	11	6	1
1	9	22	8	7	4	–
2	4	4	3	2	–	–
3	2	3	2	0	–	–
4	1	0	0	0	–	–

$r = -\cdot 0292$

that is, they are trivial accidents and the tendency to report is an important factor. Newbold's coefficients were ·200, ·213, ·261, ·311, and, bearing in mind the extraneous factors which were present, the reliance placed on them does not seem justified. Ghiselli and Brown (1948), on the other hand, report low correlation of ·25, ·13 and ·09 for "collision and non-collision" accidents, indicating "little generality". When considering home accidents it should be pointed out that there is no evidence whatsoever that there is equality of environment nor that the persons tend to be occupied in a similar way, e.g. one man's hobby may be mountaineering and another's stamp collecting.

(4) *Minor and Major Accidents*

There is no well-defined line on which to separate these two aspects. It was decided to use as minor accidents all those which caused absence from work for six days and less, and as major accidents those where the absence from work was seven days and over. The men used for this investigation were all those who shunted during the whole of the five-year period 1943–1947, i.e., the 122 men and 182 men discussed in the previous section combined. The distribution is shown

TABLE 14.

Correlation of Major and Minor (Indust.) Accidents (Injuries) 5 Years (1943–1947). 304 *Men*

Major Injuries 7+ Days	*Minor injuries 0-6 days* 0	1	2	3
0	104	41	9	5
1	62	30	9	3
2	14	10	2	1
3	6	7	–	–
4	–	–	–	1

$r = \cdot 102$

in Table 14. The coefficient of correlation is ·1023 and it is not significant. This finding is at variance with those of Farmer and Chambers discussed in Chapter III. The importance which has been attached to the correlation of minor and major accidents has been stressed. In the light of this finding it is suggested that this idea should be reviewed.

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TABLE 15.

Correlation of Accidents which Cause Injury with Accidents which Cause Damage to Property in the Same Men. (1946–1949). 157 *Men*

Mishaps	*Injuries*				
	0	1	2	3	4
0	12	11	5	1	1
1	12	4	2	2	1
2	10	3	4	2	–
3	14	2	5	1	1
4	6	8	4	1	–
5	7	2	2	–	–
6	4	4	2	–	–
7	6	1	–	1	–
8	1	1	–	–	1
9	2	2	1	–	–
10	–	–	1	–	–
11	2	–	–	–	–
12	–	1	–	–	–
13	–	1	–	–	–
14	–	–	–	–	–
15	1	–	1	–	–
16	–	–	–	–	–
17	–	–	–	1	–

$r = \cdot 028$

(5) *Correlation between the Tendency to be Injured and the Tendency to Cause Damage to Property*

These figures are shown in Table 15. They relate to 157 men over the period 1946 to 1949 inclusive (described in Chapter V), being all the men who were present for the whole of this period at the particular depot. The other factor analysed is "injury" on duty as defined previously in this work. The correlation coefficient between these two factors is ·028 and is not significant, suggesting no relationship between the tendency to injure oneself and the tendency to damage property. If it is true as Farmer (1926) states that "from a psychological point of view an accident is merely a failure to act correctly in a given situation, and the relative gravity of the result of such a failure must be regarded as irrelevant", then we should expect some correlation between these tendencies which are after all two aspects of "accidents". Our findings suggest that these two aspects of accidents are not related.

(6) *Accidents which Cause Damage to Property*

Certain data concerning the accidents which cause damage to property can be analysed further. There are much fewer data here than in the case of injuries. Approximately four years of records are available, and they relate to 157 men who were present during the whole period. The same techniques are applied to these facts as to the injuries, viz.:

(*a*) The influence of age and experience is assessed by the correlation coefficient.
(*b*) Accident proneness is measured by the correlation of accidents in various time periods.
(*c*) Poisson and negative binomial distributions are fitted to the observed distribution.

(*a*) *The influence of age and experience.*—The age of each man at the beginning of 1946 is correlated with the number of mishaps sustained by him during the four-year period 1946–1949. The correlation coefficient is ·048 and is not significant. In a similar way the correlation between experience of shunting prior to 1946 and the number of mishaps sustained during the period 1946–1949 is ·034.

(*b*) *and* (*c*). *Accident proneness in regard to mishaps.*—The exposure period 1946 to 1949 has been divided into four yearly periods (1946 contains about ten months of records), and the correlations between mishaps to each man during these periods are shown in Tables 16A, B, C, D.

These coefficients are significant, and according to our previous arguments suggest proneness. It is to be noted that the factors of age and experience have been shown to have no correlation with these accidents.

The fitting of Poisson and negative binomial distributions to the observed distribution of the four-year period is shown in Table 17. The negative binomial gives a good fit with $P = \cdot 428$,

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TABLE 16

Correlation Between Mishaps during Various Periods, 1946–1949. 154 *men*

A. *Mishaps* 1946 *against* 1947

Mishaps 1947 \ *Mishaps* 1946	0	1	2	3	4	5	6	7	8
0	63	12	6	1	–	–	–	–	–
1	20	9	2	1	2	–	–	–	–
2	7	9	3	1	–	–	–	–	–
3	5	3	1	–	–	–	–	–	1
4	1	2	–	–	1	–	–	–	–
5	1	–	–	–	–	–	–	–	–
6	1	–	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–	–
8	1	–	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–	–	–
11	–	–	–	–	–	–	–	–	–
12	–	1	–	–	–	–	–	–	–

$r = \cdot 193$

B. *Mishaps* 1947 *against* 1948

Mishaps 1948 \ *Mishaps* 1947	0	1	2	3	4	5	6	7	8	9	10	11	12
0	49	13	6	–	1	1	–	–	–	–	–	–	–
1	21	11	7	5	3	–	–	–	–	–	–	–	–
2	10	7	1	–	–	–	1	–	–	–	–	–	–
3	2	2	3	3	–	–	–	–	1	–	–	–	1
4	–	–	–	1	–	–	–	–	–	–	–	–	–
5	–	–	2	1	–	–	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–	–	–	–	–	–
8	–	1	1	–	–	–	–	–	–	–	–	–	

$r = .326$

C. *Mishaps* 1948 *against* 1949

Mishaps 1949 \ *Mishaps* 1948	0	1	2	3	4	5	6	7	8
0	39	23	8	0	–	1	–	–	1
1	16	13	4	5	–	1	–	–	–
2	12	8	4	5	–	–	–	–	–
3	2	2	1	1	–	–	–	–	–
4	1	1	1	1	1	1	–	–	1
5	–	–	–	–	–	–	–	–	–
6	–	–	1	–	–	–	–	–	–

$r = \cdot 309$

D. *Mishaps* 1946 *and* 1947 *against* 1948 *and* 1949

Mishaps 1948 *and* 1949 \ *Mishaps* 1946 *and* 1947	0	1	2	3	4	5	6	7	8	9	10	11
0	30	6	1	–	–	1	–	–	–	–	–	–
1	14	5	11	6	2	2	–	–	1	–	–	–
2	11	7	4	3	3	2	1	–	–	–	–	–
3	6	6	–	–	1	–	–	–	–	–	–	–
4	2	4	1	3	–	1	–	–	1	–	–	1
5	–	3	4	1	–	1	–	–	–	–	–	–
6	–	–	–	2	–	–	–	–	–	–	–	1
7	–	–	1	–	1	–	–	–	–	–	–	–
8	1	–	–	1	–	–	–	–	–	–	–	–
9	–	–	–	–	1	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–	–	–	–	–	–
11	–	–	–	–	–	–	–	–	–	–	–	–
12	–	–	–	1	–	–	–	–		–	–	–

$r = \cdot 355$

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The results are as follows:

Periods	*Coefficient of Correlation*
1946 against 1947	·193
1947 ,, 1948	·326
1948 ,, 1949	·309
1946 and 1947 against 1948 and 1949	·355

whereas the Poisson fit is an extremely unlikely one with a P value of less than ·001. Fig. 15 shows the cumulative distribution of the estimated "true accident liability", and also the cumulative distribution of the fitted Negative binomial. It shows a fairly wide spread of liabilities, suggesting that there is a reasonable measure of difference between the liabilities of the individual shunters.

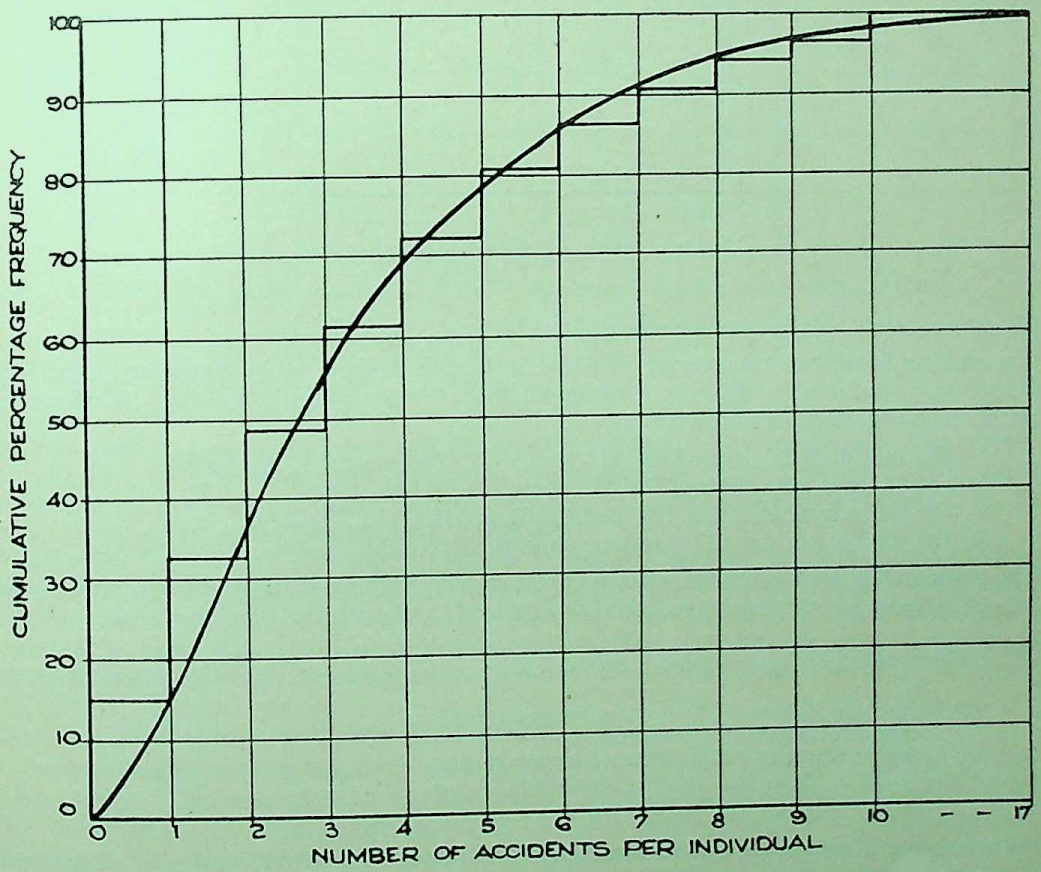

FIG. 15.—Estimated cumulative distributions of true accident liability and negative binomial fitted to observed distributions of accidents. 157 shunters; industrial mishaps; 4 years.

The findings in respect of the correlation and curve fitting lead to the conclusion that, in regard to these mishaps, we are examining a group of persons who vary in accident proneness. Furthermore this proneness is of practical importance, because it is statistically evident in four years of data. It has been shown that there is no correlation between these mishaps and the injuries sustained by the men. The data examined up to this point indicate that for practical purposes "injury" proneness is not significant, whereas "damage" proneness in the same men is significant. This conclusion will be followed up in a later section.

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TABLE 17

Comparison of Observed with Theoretical Distributions. Mishaps of 157 *Men during* 1946–1949

Number of Mishaps	*Number of Men*		
	Observed	*Calculated Poisson*	*Calculated Neg. binomial*
0	30	4·79	23·8
1	21	16·71	26·9
2	19	29·16	25·2
3	23	33·92	20·8
4	19	29·59	16·5
5	11	20·65	12·6
6	10	12·01	9·5
7	8	5·99	7·0
8	3		5·2
9	5		
10	1		
11	2		
12	1	4·18	9·5
13	1		
14	0		
15	2		
16	0		
17	1		
Total, .	157	157	157
Mean,	3·4904	$\chi^2 = 125$ $P < \cdot 001$	$\chi^2 = 7 \cdot 65$ $P = \cdot 428$

(7) *Comparing the "Standardised Accident Liabilities"*

The accident liabilities of the groups examined have been standardized by the method mentioned in the previous section on p. 375, viz., by estimating the distribution of λ/m. Fig. 16 reflects the ogives of these distributions in respect of—

(1) The industrial injuries of the 122 men who shunted for eleven years.
(2) The 182 men who shunted for five years.
(3) The home injuries of the 122 men mentioned in (1) during eleven years.
(4) The mishaps of the 157 men who shunted during the four years 1946 to 1949.

The standard deviations of the value λ/m which has mean value equal to unity are shown below. The value for the "sickness liability" discussed in Chapter VIII is also shown.

"Standardized Accident Liability" estimated for:—	*Standard deviation ± Standard Error.*
(1) Industrial accidents of 122 shunters during eleven years . . .	0·54±0·10
(2) Industrial accidents of 182 shunters during five years . . .	0·27±0·17
(3) Home accidents of 122 shunters during eleven years . . .	0·78±0·17
(4) Mishaps of 157 shunters during four years	0·78±0·08
Sicknesses of 302 shunters for five years	0·64±0·04

Although the distributions of the "standardised liabilities" for the various types of accidents are somewhat similar, it must be observed that the same man will not occupy his same position in the curve when different types of accidents are involved. This is shown by the fact that there is no correlation when the various types of accidents occurring to the same persons are examined. A man might be "very prone" with regard to, say, industrial injuries, and not prone with regard to home injuries.

(8) *The Correlation between Accidents and Sickness in the Same Men*

The sickness experience of shunters is dealt with in another section of the thesis. All sicknesses that necessitate being away from duty are recorded. It is thought that the tendency to take advantage of liberal sick-fund benefits does play some part, i.e., we are measuring in part the tendency to report rather than the tendency to be sick. The correlation between accidents

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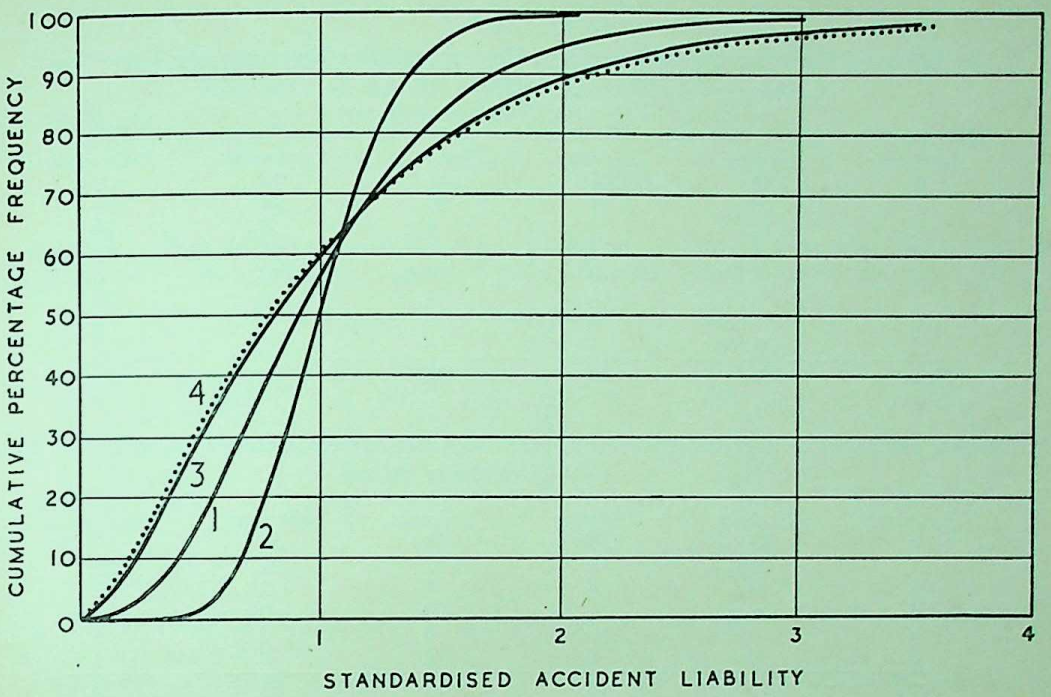

FIG. 16.—Standardised accident liabilities (cumulative frequency distribution of γ/m.

1. Industrial injuries. 122 Men; 11 years.
2. Industrial injuries. 182 Men; 5 years.
3. Home injuries. 122 Men; 11 years (same Men as in 1).
4. Mishaps. 157 Men; 4 years.

and sickness for 302 men for five years and 122 men for eleven years are calculated. The correlation coefficients are ·069 and ·0618, suggesting no relationship between the tendency to have accidents and to have illness. The correlation coefficient between accidents and days sick for the 122 men during eleven years is ·2338 and is significant.

Farmer and Chambers (1929) found positive correlations between accidents and sicknesses in groups of R.A.F. apprentices and in dockyard apprentices, but they stated that it was possible that the relationship may have been due to a tendency to report both accidents and sicknesses. Newbold (1926) also found a positive correlation between minor accidents and sicknesses reported to the ambulance-room and not necessitating more than a few hours away from duty.

(9) *Removing the Men with the Highest Accident Rate*

If individual differences in accident liability exist, then removing those men who have most accidents during one period should lower the accident rate during the following periods. This method of reducing accident rates has been tried by a taxi company and good results reported; but other factors such as punishment for accidents are involved, so it is difficult to know what was actually happening. Theoretical examples are tried with the shunters. Two groups are used; firstly, all men who began in 1943 and stayed for at least four years, and secondly, all men who began in 1944 and stayed at least three years. The frequency distributions for the first group in the four yearly periods are shown in Table 18A. Then the thirteen men with the highest accident rate (i.e., those who had two and three accidents in the first year) are removed from the figures for the next three years and the remainder shown in Table 18B. As will be seen, this procedure does not cause the mean accident rate to differ appreciably from what it was when the thirteen men are included. The t test applied to the difference between the mean of the thirteen men removed and the means of the remaining 73 men shows no significant difference. A similar result is obtained in the other group as shown in Table 18C. This is what we expect from a "chance" distribution.

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TABLE 18A, B, C

The Effect of Removing the Men with the Highest Accident Rate after the First Year

A. *Shunters who Joined in* 1943 *and Shunted for Four Years*

Number of Accidents	*Number of Persons*				
	1st year	*2nd year*	*3rd year*	*4th year*	*Total years*
0	45	65	61	58	20
1	28	14	20	24	22
2	12	5	4	4	26
3	1	2	1	0	6
4	0	0	0	0	6
5	–	–	–	–	5
6	–	–	–	–	0
7	–	–	–	–	1
Total	86	86	86	86	86
Mean	·639	·360	·360	·348	1·51

B. *Shunters who Joined in* 1943 *and Removing Thirteen Men with Highest Accident Rate after First Year*

Number of Accidents	*Number of Persons*				
	1st year	*2nd year*	*3rd year*	*4th year*	*Total years*
0	45	56	54	50	20
1	28	12	15	21	22
2	0	4	4	2	22
3	0	1	0	0	3
4	0	0	0	0	5
5	0	0	0	0	1
Total	73	73	73	73	73
Mean	·383	·315	·315	·342	1·235

C. *The Accident Rates for the Shunters who Joined in* 1944 *and Shunted for Three Years*

	1st year	*2nd year*	*3rd year*
Mean accident rate of 104 men	·557	·355	·317
After removing 10 men with highest rate in 1st year—94 men	·393	·361	·329

(10) *The Probability of the Repetition of Similar Accidents*

A method of studying the repetition of accidents was described by Archibald and Witfield (1947). This method does not deal with accident proneness directly but with a related factor. It does not require equal exposure to risk, and hence all the accident data can be used. In order to carry out the procedure we have grouped certain types of accidents, e.g., all coupling accidents are put together and similarly all tripping accidents. A complicating factor arose in respect of the unclassified accidents, and as no other method was available they were treated as a group in themselves with the hope that this procedure would not introduce too great an error. The relevant data are set out in the tables which follow. The first table shows the number of each type of accident and the number of possible pairs of each type. This number is calculated by the formula $x(x-1)\frac{1}{2}$, where x is the number of accidents observed.

Type of Accident	*Number of Accidents*	*Number of Pairs*
Tripping and stumbling	150	11,175
Riding, jumping on and off vehicles	229	25,992
Coupling	423	89,253
Uncoupling	76	2,850
Adjusting buffers	172	14,706
Adjusting brakes, riding	38	703
,, ,, walking	56	1,540
Foreign Body in eye	64	2,016
Contacting stationary objects while riding	16	120
Adjusting vacuum pipes	7	21
Burnt by steam from engine	2	1
Not classified, but coupling or uncoupling	50	1,225
Not classified	168	14,028
Total accidents	1,451	163,630

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If two accidents occur to an individual we may calculate the chance that they are of the same type.

There were altogether 1,451 accidents and hence the possible number of pairs is

$$1{,}451 \times 1{,}450 \times \tfrac{1}{2} = 1{,}051{,}975.$$

The probability of two accidents being of the same type is therefore

$$\frac{163{,}630}{1{,}051{,}975} = \cdot 15554.$$

The next Table reflects the distribution of accidents among the men who had two or more accidents each, and the possible number of pairs which this distribution entails, viz., 1,062.

Accidents	*Number of Men*	*Number of Pairs*
0	—	—
1	—	—
2	213	213
3	109	327
4	34	204
5	15	150
6	7	105
7	3	63
		1,062

Hence the expected number of pairs of accidents *of the same type* is $1{,}062 \times \cdot 15554 = 165 \cdot 18$. The observed number is 172.

The observed and the expected number of Pairs of the same type associated with the same man are shown in the table below.

Pairs Associated with the Same man	*Observed*	*Expected*
Accident of Same Type :		
Tripping and stumbling	15	11·3
Riding—jumping on and off	32	26·2
Coupling	79	90·1
Adjusting buffers	10	14·8
Not classified	17	15·2
All other categories	19	8·0
Accidents Not of the Same Type	890	896·8
Total	1,062	1,062

$\chi^2 = 18 \cdot 51$; $P = \cdot 005$.

The test of goodness of fit gives a $P = \cdot 005$, but an inspection of the data reveals that the overwhelming discrepancy is in the "all other" groups. The more important groups show a fairly close similarity between the observed and expected numbers. The conclusion which we draw is that we have no clear evidence that either learning to avoid accidents takes place, or, on the contrary, that there is a tendency to repeat the same kind of accident. If it is true that they do not "learn by experience", then the theory of proneness as the important factor becomes more tenable.

Conclusions.

Groups of shunters have been examined for evidence of accident proneness by fitting Poisson and negative binomial distributions to the observed distributions and by correlating accidents during various periods. It is concluded that accident proneness for industrial injuries is a factor in the group which shunted for eleven years, but in a degree which is not important practically because it requires eleven years before this fact becomes statistically verifiable, and the degree of difference is small.

Three other relationships of accidents have been examined by means of the correlation technique, viz., minor and major accidents, accidents at work and accidents at home, and accidents and mishaps. In all these cases the correlation coefficients are not statistically significant.

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These facts lead us to propose that accident proneness is not a general factor, but that it operates in a specific type of event in a specific environment, and that it may alter in an individual in accordance with his changes of activity.

Mention has been made of the contrary findings and conclusions of other authors, and reasons suggested as to why their conclusions are not thought to be wholly warranted. The fundamental reasons for their errors have been discussed in the chapter on Problems of Classifications, viz., the classification of major with minor accidents, the confusion of the tendency *to report* accidents with the tendency *to have* accidents, and the use of the word "accident" to mean a variety of events.

As far as shunters' injuries are concerned (and these must be classed as serious accidents) there is evidence that there is no relationship between those which cause an absence of seven days or more and those which cause an absence of less than seven days, between home and industrial accidents, and between personal injuries and mishaps which cause damage to property.

With regard to injuries sustained away from work (home injuries) the evidence for marked proneness is even flimsier than it is in the case of the industrial injuries. However, in the case of mishaps which cause damage to property there is ample statistical evidence that proneness does exist. This type of accident involves no danger to the shunter, and is purely a question of damaging property belonging to the administration.

It has been suggested that this kind of accident has increased recently, and this increase has been linked with the lower general state of morale of the labour market. On the other hand, it is noticed that the injury rate of shunters has been remarkably constant during the period under observation. The suggestion is made that the "damage to property" type of accident is connected with traits of personality and character which are liable to be influenced by such factors as discipline and a sense of social responsibility, whereas the factors underlying injury are more stable and not so readily influenced.

V(*c*). Further Observations about Accident Proneness.

Serious and trivial accidents.—It appears from an examination of the causes of accidents in a hazardous environment that "chance" factors play an important part. Reliable statistical evidence for accident proneness among shunters in respect of serious injuries appears only after eleven years have passed and the differences are not large. When the environment is safe the injuries are too few to analyse reliably. With regard to minor injuries enough has been said to show that difficulties connected with their classification lead to serious doubts about drawing conclusions.

Selection.—It has been emphasized that as the period of observation lengthens the group under observation becomes more selected and the selection may be associated with the very factor which we are studying. Furthermore it is surmised that all occupational groups undergo some form of selection *before* the members enter the occupation. Shunters are generally drawn from a limited economic group and the educational qualification required is the passing of Standard VI. Some persons may fear the danger of the occupation and others, it has been suggested, may be drawn to dangerous work.

This process of selection tends to make generalization from evidence derived from particular groups a difficult matter.

Hypothesis not adequately investigated.—One aspect of the statistical approach which has not been adequately followed is the point of view which postulates that the occurrence of an accident makes the probability of another accident either *more or less* likely, i.e., the biased distribution formulated by Greenwood and Woods. Stated in another way, the occurrence of an accident makes the victim "nervous" and so more liable to another accident, or on the contrary, it teaches him to avoid accidents. It is possible that mathematical models to suit these situations can be found which can adequately explain accident data. It is further possible that some accident data consist of mixtures of various trends, some with "proneness", some with learning, some with nervousness and some who change from one to the other. At present our methods examine the distribution of the end-results, so that our model may not be the true reflection of the underlying processes.

Theories of causes of accident proneness.—An immediate result of the announcement of diffe-

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rences in accident liability was the investigation of the problem of the detection and measurement of the susceptibility to accident by appropriate tests. This was important, because if it could be done it followed that persons who were unsafe could be placed in occupations involving the minimum of risk. At first it was thought that psychological differences relating to skill would play the predominant part, and Farmer and Chambers carried out investigations to elucidate this factor by employing certain laboratory tests (1929). They found correlations between the tests and accidents but these were of a low order. The accidents which were dealt with were of a minor character and the assumption was made that they were "indicators" for major accidents. We have given evidence to show that the assumption is, at any rate, not always justified.

Later, other psychological factors were invoked. The work of Biesheuval (1949) with Air Force pilots is an example of the best of this type of work. Aptitude testing was done prior to the flying training. Subsequently a group who sustained accidents was compared with a group who had not, and significant differences were found in certain types of skills, in temperament factors, and in personality attributes.

Since various types of accidents are not necessarily correlated it is assumed that the factors underlying the accidents will vary, and hence it must not be supposed that the factors which hold good for one type of accident also apply to any other type of accident. It is known that flying involves particular aspects of personality such as the possibly innate fear of falling. Other kinds of accidents involve other factors. For instance, it is suggested that the personality factors involved in injuring oneself and in damaging property are different.

Accident liability is related to the degree of exposure to the particular risks, and this exposure, in some occupations, is a function of initiative and other desirable characteristics. Thus there seems to be the risk, if selection solely on accident proneness is used, of keeping out the best men for the job, e.g., the potential V.C.

Investigations with a similar orientation were carried out by Dunbar (1943), Tillman and Hobbs (1949), Wong and Hobbs (1949), and Adler (1941). These were discussed in the previous section when dealing with methods for investigating accident proneness: Most of the work is of an unsatisfactory nature and does not compare in method with that of Biesheuval or Farmer and Chambers. The clinical findings of these workers are rather vague, and are biased by their preconceived psycho-analytic theories.

The psycho-analytic school has had widespread influence and some of its followers have formulated theories about accident proneness. In general they maintain that accidents are caused by unconscious desires or purposiveness, e.g., Ernest Jones (1933), after explaining how unconscious impulses may modify conscious activity, states: "Probably four-fifths of the terrible death roll on our roads comes about in the same way, by the driver's unconscious interfering with his doing the right thing in an emergency". Some members of this school postulate, also, an unconscious death wish. The evidence they bring forth is clinical, but in so far as their theory plays a large part in forming the type of clinical evidence which they produce, it is not reliable.

Accidents and accident death-rates vary from occupation to occupation, as shown for example in various grades of railway employees. It has been shown that during five years nine shunters were killed by accidents whilst on duty. Clerical staff outnumber shunters by approximately three to one. Yet no clerks were killed by accidents on duty. As a further check, the suicides and other non-industrial accidental deaths of clerks were examined for five years, only to find that there was only one such death. This would mean that the persons in these different occupations must have differing quantities of unconscious desire to be hurt or killed, and that they must choose their jobs in accordance with the way the inherent danger of the job meets their unconscious desire to be injured. This is an idea for which there is no substantial evidence. The opposite has in fact been suggested as a possible theory, viz., that those persons who have the tendency to cause accidents *avoid* dangerous work. This seems to be a reasonable proposition more in keeping with the evidence than the psycho-analytic view. When the latter school finds clinical evidence that a person had an accident when he was about to face an unpleasant situation, they say that he unconsciously desired to have the accident so that he could avoid the unpleasant situation. This is well exemplified in Dunbar's work. But there is another approach which seems more reasonable and does not require these unproved hypotheses. It is conceivable that a man who is on his way to an unpleasant interview, for example, may be "nervous" to such a degree that he responds badly and sustains a street accident. This is not the same as saying that he unconsciously "wished

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to have the accident *in order that*" he could escape the consequences of the interview without losing face.

The present position.—The evidence suggests that accident proneness on a fairly wide scale of differences exists for specific types of serious accidents, and that over and above this factor are the larger number of unknown or "chance" variables which alter from occupation to occupation, and affect all persons in each occupation more or less equally when the sum total of their effects are added. Compared to the "chance" factors the factor of proneness is not of practical importance for experienced shunters. It is the purpose of industrial psychology to unravel these unknown causes in the same way as it has done for factors such as age, experience, training, hours of work, fatigue, diet, light, ventilation, etc., occurring both in the environment and in the person. So far the record of the industrial engineer and psychologist in respect to accident prevention has been good, but is there not now a tendency on the part of psychologists to lay all the blame on "proneness"? It would appear that more investigations of serious accidents are needed to establish what part proneness plays in various types of occupation.

The assertion that most accidents are due to human failures.—How much truth is there in the assertion that nearly all accidents are the result of human failure, and that usually personality factors are involved? While this assertion may be literally true, it tends to hide a good deal of essential fact. It is true enough that most serious accidents take place when a person does a certain action, and one might say: "If he had not done this there would have been no accident". The machine involved went through its usual movements and was not responsible. What has been shown is that humans have accidents when using machinery. With some machinery under certain circumstances the probability of accident is higher than with other machinery. This must be accepted as the normal state of affairs which can be lessened by improving certain conditions which have been mentioned, e.g., training, etc. But what is not yet shown is that it is a human "failure" rather than a human "normal" to have accidents. There is a tendency on the part of some writers to judge that people are "defective" as judged by some perfectly ideal standard which does not exist and never will exist. If a large amount of differing susceptibility or "proneness" were shown then it might be contended that a human failure takes place. If it is not shown that proneness exists then what is proved is that "to err is human", and that the quantity of errors varies according to certain environmental circumstances. The temptation to jump to the conclusions which follow as if proneness did exist as a practical measure is great, but it should be resisted until more work throws more light on the subject.

VI. Some Personal Factors in Relation to Sickness

The arguments about accident proneness suggested a similar approach for the problem of sickness; two aspects are examined—the relation between major and minor sickness and the existence of "sickness proneness". Ten days and over was chosen arbitrarily as the criterion of major sickness. Using the experience of 122 men who shunted for eleven years three correlations are examined in Tables 19, 20 and 21, with the following results:

(1) Minor sicknesses occurring during two periods, six years and five years: coefficient of correlation, ·661.
(2) Major sicknesses occurring during the same two periods: coefficient of correlation, ·507.
(3) Major sicknesses against minor sicknesses for the eleven years: coefficient of correlation, ·527.

The coefficients of correlation are all significant.

The distribution of sicknesses.—By using a line of reasoning similar to that used when discussing accident proneness, a distribution of sicknesses can be looked upon as a series of Poisson distributions. Table 22 shows various distributions fitted to the distribution of sicknesses of the 302 shunters during the five-year period 1943–1947. The Poisson and negative binomial give unlikely fits, and a third was tried, viz., the Neyman type A curve. This gave a good fit with $P = \cdot 825$. This distribution was described by Neyman (1939) when dealing with "contagious" data. Feller (1944) has shown that the distribution can also be derived by a process similar to the one used in deriving the negative binomial mentioned in connection with accident proneness. On p. 390 we

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TABLE 19

Correlation of Minor Sicknesses during 6 *years* (1937–1942) *against* 5 *years* (1943–1947). 122 *Men.*

Minor Sicknesses, 1937-1942	*Minor Sicknesses*, 1943–1947																			
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	20	–	–	2	–	–	1	–	–	–	–	1	–	–	–	1	–	–	–	–	–
1	2	2	2	2	3	–	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–
2	2	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3	3	–	–	3	1	2	–	–	1	–	1	1	–	–	–	–	–	–	–	–	–
4	1	1	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5	–	–	1	3	1	1	1	2	–	2	–	–	–	–	–	–	–	–	–	–	–
6	1	–	1	1	1	2	–	1	1	1	–	–	–	–	1	–	–	–	–	–	–
7	1	–	–	2	1	1	2	–	–	–	1	–	–	–	–	1	–	–	–	–	–
8	–	–	1	–	1	1	–	–	–	–	1	2	–	–	–	1	–	–	–	–	–
9	–	–	–	–	1	–	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–
10	1	–	–	–	–	1	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–
11	–	–	1	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–
12	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
13	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
14	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–
15	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	1	–	–	–	–	–
16	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
20	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–

$r = \cdot 661$

TABLE 20

Correlation of Major Sicknesses during 6 *Years* (1937–1942) *with* 5 *Years* (1943–1947). 122 *Men.*

Major Sicknesses 1937–1942	*Major Sicknesses* 1943–1947											
	0	1	2	3	4	5	6	7	8	9	10	11
0	32	8	4	1	2	3	–	–	1	–	–	–
1	5	4	6	1	2	2	–	–	–	–	–	1
2	1	1	2	3	1	–	–	–	–	–	–	–
3	2	3	–	2	–	3	2	2	1	–	–	–
4	–	–	1	1	–	–	2	–	2	1	2	–
5	–	–	3	–	2	–	–	1	–	–	–	–
6	1	–	–	3	–	–	–	1	–	–	–	–
7	–	–	–	–	–	–	–	1	–	–	–	–
8	–	–	–	–	–	–	–	–	1	–	1	–
9	–	–	–	1	–	–	–	–	1	–	–	–
10	1	–	–	–	–	–	–	–	–	–	–	–
11	–	–	–	–	–	–	–	–	–	–	–	–
12	–	–	–	–	–	–	–	–	–	–	–	–
13	–	–	–	–	–	–	1	–	–	–	–	–

$r = \cdot 5075$

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TABLE 20A

Correlation of Sick Absences with Industrial Injuries. 302 *Men.* 5 *Years*, 1943–1947

Sick Absences	*Injuries* 0	1	2	3	4	5	6	7
0	9	8	6	2	–	–	–	–
1	4	1	1	1	–	–	–	–
2	4	7	2	–	1	–	–	1
3	7	11	4	–	1	–	–	–
4	9	9	2	–	2	1	–	–
5	7	7	6	1	1	–	–	–
6	6	6	4	2	–	–	–	–
7	7	7	3	2	–	–	–	–
8	6	10	4	2	–	–	–	–
9	8	9	3	2	1	–	–	–
10	5	3	5	1	–	–	–	–
11	1	4	1	4	2	–	–	–
12	6	5	5	1	–	–	–	–
13	5	2	1	2	1	–	–	–
14	4	2	–	–	–	–	–	–
15	4	4	–	–	2	–	–	–
16	–	–	3	–	–	–	–	–
17	1	3	1	2	–	–	–	–
18	–	–	2	1	–	–	–	–
19	2	–	–	1	1	–	–	–
20	2	1	–	1	–	–	–	–
21	–	–	–	1	–	–	–	–
22	2	1	–	1	–	–	–	–
23	2	–	–	1	–	–	–	–
24	1	1	–	1	–	–	–	–
25	–	–	–	–	–	–	–	–
26	1	–	–	–	–	–	–	–
27	–	1	–	–	–	–	–	–
28	–	–	–	–	–	–	–	–
29	–	–	–	–	–	–	–	–
30	–	–	–	–	–	–	–	–
31	–	1	–	–	–	–	–	–

$r = \cdot 0609$

showed the standard deviation of the "standardised sickness liability" of this group compared with the " standardised accident liabilities" of the shunters.

Here we have good evidence of the existence of "sickness proneness", and we can say that the same persons, in general, who have many sicknesses during one period tend to have many sicknesses during the next period, and that the same persons who have minor sicknesses tend to have major sicknesses. Now the statement that a small proportion of the men are responsible for a large proportion of the illnesses becomes meaningful.

Acknowledgments

I wish to thank the General Manager of the S.A.R. for permission to publish this work.

For assistance in statistical methods I have to thank Mr. J. E. Kerrich of the University of Witwatersrand, and also Mr. S. H. Sichel of the Personnel Research Bureau (S.A.). I am grateful to Dr. P. Armitage for his invaluable assistance in the preparation and reading of this paper, and to Dr. J. O. Irwin and Professor Bradford Hill for their encouragement and help.

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TABLE 21

Correlation of Major Sicknesses with Minor Sicknesses during 11 *years* (1937–1947). 122 *Men.*

Minor Sicknesses	*Major Sicknesses* 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	17	1	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
1	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2	2	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–
3	1	2	1	1	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
4	1	–	–	1	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
5	1	3	1	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6	1	–	–	1	–	–	1	1	–	–	–	1	–	–	–	–	–	–	–	–
7	–	4	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–
8	3	–	2	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–
9	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10	2	–	1	1	–	–	2	–	1	–	–	–	–	–	–	–	–	–	–	–
11	–	–	–	–	2	1	1	–	–	1	–	–	1	–	–	–	–	–	–	–
12	1	–	1	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13	–	–	–	1	–	1	–	1	–	1	1	–	–	–	–	–	1	–	1	–
14	1	–	1	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–
15	–	2	–	1	–	–	1	–	–	–	1	–	–	–	1	–	–	–	–	–
16	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
18	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
19	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
20	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–
21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
22	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–
23	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
26	–	–	–	–	1	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–
27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
29	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
30	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
31	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
36	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
37	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
38	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
40	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–

$r = \cdot 527$

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TABLE 22

Comparisons of Observed with Calculated Sickness Distribution. 302 *Shunters.*

302 *Shunters. Five Years*, 1943–1947

Number of Sicknesses	*Observed*	*Calculated*		
		Poisson	*Neg. Binomial*	*Neyman Type A*
0	25	·08	8·1	28·0
1	7	·66	15·3	8·1
2	15	2·71	20·8	14·7
3	23	7·43	23·8	19·2
4	23	15·31	25·0	21·0
5	22	25·23	24·9	21·2
6	18	34·64	23·9	20·9
7	19	40·78	22·7	20·3
8	22	42·00	20·7	19·4
9	23	38·45	18·5	18·1
10	14	31·68	16·4	16·6
11	12	23·74	14·3	14·9
12	17	16·30	12·3	13·2
13	11	10·33	10·6	11·5
14	6	6·08	9·0	9·9
15	10	3·34	7·5	8·4
16	3	1·42	6·3	7·3
17	7	·83	5·3	5·9
18	3	·69	4·4	4·9
19	4	—	3·6	4·0
20	1	—	3·0	3·2
21	4	—	2·5	
22	4	—	2·0	
23	3	—	1·1	11·3
24	3	—	—	
25	0	—	—	
26	1	—	—	—
27	1	—	—	—
28	0	—	—	—
29	0	—	—	—
30	0	—	—	—
31	1	—	—	—
	302	302	302	302
χ^2	—	700	43·4	11·524
P	—	·001	·01	·825

The fitting of the Neyman Type A Distribution to the above data was suggested by Mr. J. S. Maritz of the National Institute for Personnel Research.

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Discussion on Dr. Adelstein's Paper

Dr. J. O. Irwin: In proposing a vote of thanks to Dr. Adelstein let me say how much I personally regret that he is unable to be present to-day.

This is the most comprehensive treatment of a body of actual data by statistical methods which have become associated with the concept of accident proneness that I have seen since Miss Newbold's classical work, presented to this Society in 1927. It seems to me altogether good that any of us whose thinking on the accident problem has got into a groove should be jerked out of it by this reconsideration of the whole question. The present paper cannot altogether be dissociated from a paper by Arbous and Kerrich in the December, 1951, number of *Biometrics*. Whereas Dr. Adelstein's interest is primarily in the shunters on the South African Railways, Arbous and Kerrich, who made use of Adelstein's data, are clearly more concerned with the general psychological problem of accidents and with the mathematical theory of accident proneness. All three authors are critical of a good deal that has been said about accident proneness and have tried to restate the whole position.

The doctrine of "accident proneness" in its most extreme form I conceive to be this: "Suppose that a group of people of the same age, sex and experience are put in a standard environment where they are each exposed to the same risk of accident. The probabilities per unit of time of their incurring an accident are in general not equal, or, what is the same thing, the *expected* number of accidents in a given time differs from one person to another. If these expected numbers are $\lambda_1, \lambda_2, \lambda_3 \ldots$, etc., then if the environment is changed in the same way for them all, these numbers will remain in the same proportion. In other words, relative liability to accident in a constant environment is the same for all environments. It is an intrinsic property of the individual —his "accident proneness". There is no doubt that, put in this extreme form, the doctrine is false. Dr. Adelstein and the other two writers I have mentioned have made an extensive survey of the literature and have, especially in the more recent literature, found a number of statements of this kind which they rightly condemn. It does, however, seem worth while pointing out that the pioneers, Greenwood and Woods, Newbold, and Yule, were well aware of the limitations of the method of research which they had devised. Further, I do not believe that Farmer and Chambers ever thought anything of the kind. None of these authors ever suggested that proneness was more that one of the factors involved in accident causation. Arbous and Kerrich, whose paper is extremely well-written, say, "It will be shown later in this study that it is a very unfortunate but real fact that our knowledge of this concept has hardly proceeded further, and in some respects has suffered a reverse, from the time when Greenwood, Woods, Yule and Newbold undertook their classical studies in 1919 and 1926", and again, "Greenwood and Woods in their original report recognized that individual susceptibility sheltered a motley host of motives and factors which will be very difficult indeed to separate and measure". However, I would join issue with them when, after observing that it is very difficult to decide whether non-homogeneity in an accident distribution is due to non-homogeneity of the environmental causes or of the personal causes, they say, "Surely the essence of accident causation is the rather intricate inter-relationship which exists between the individual and the environment and the influence of one cannot be appreciated without considering its interaction with the other, and to attempt to separate the two is about as profitable as attempting to unravel the respective influences in the heredity *vs.* environment controversy". I would submit that a very great deal has been learnt by the effort to evaluate the relative importance of nature and nurture. Sometimes one and sometimes the other is the limiting factor, but by the endeavour to learn the precise conditions under which either of these alternatives occurs an enormous contribution has been made to biological science. The pioneers, it seems to me, provided us with a technique which helps to ascertain the importance of the personal factor in accidents. They would not have claimed more. The mathematical methods of to-day are clearer and more elegant; in one respect Kerrich has made a new contribution by finding the bivariate analogue of the negative-binomial distribution for accidents in two distinct periods of time.

I think Dr. Adelstein may have misunderstood the passage from Greenwood and Woods (1919) which he quotes on p. 356. I would agree that the possible consequences of an accident may well affect the prior actions of the worker. The point is whether they will affect the prior actions of all workers in an equal manner. If not, there are likely to be differences in accident proneness. The dice throws refer to the differences in the number of accidents sustained by workers who are equally accident-prone, not to differences between workers who differ in accident proneness. I entirely agree with both paragraphs headed "Comment" (pp. 377–78), which seem to summarize the present position very fairly.

I have found the paper very stimulating. Indeed when reflecting on the fallacy, probably

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known to you all, that it does not follow if, say, 50 per cent. of accidents are caused by 40 per cent. of workers, that accident proneness is demonstrated, because the same sort of thing happens in a random distribution, I came across a new way of deriving the Poisson—at any rate new to me.

It starts from the postulate that if accidents are occurring at random, the mean number sustained in a given exposure time should be independent of the number already sustained.

Let m be the mean number of accidents for a given exposure time, $p(r)$ the probability that an individual sustains r accidents. By hypothesis the expected number of accidents sustained in the given exposure time by any individual will be m irrespective of the number he has already had.

Now $\Sigma rp(r) = m$ and $rp(r)$ is the relative frequency of accidents incurred by people who have had r accidents in all. It is therefore the relative frequency of accidents incurred by people who have had $(r - 1)$ accidents other than the accident in question. The mean number of such accidents is therefore $\Sigma(r - 1)\{rp(r)/m\}$, which by hypothesis is equal to m. Hence:

$$\Sigma(r - 1)rp(r) = m^2.$$

Similarly $(r - 1)rp(r)$ is the relative frequency of accidents among people who have had $(r - 2)$ accidents other than the first two and thus

$$\Sigma(r - 2)\{(r - 1)rp(r)/m^2\} = m$$

or

$$\Sigma(r - 2)(r - 1)rp(r) = m^3.$$

Proceeding in this way we find that the kth factorial moment is m^k.

Now it is difficult to put oneself in the position of someone who had not heard of the Poisson distribution before, but I think a somewhat mathematically minded statistician who had got so far would write down the factorial moment generating function and see that $\Sigma p(r)(1 + t)^r = e^{mt}$. The solution $p(r) = cm^r/r!$ would immediately suggest itself and by substitution he would find $c = e^{-m}$.

Even more important than this is the fact that if the same process is applied to any frequency distribution of accidents, we find that the ratio of the kth to the $(k - 1)^{\text{th}}$ factorial moment gives the mean number of accidents subsequently incurred by persons who have had k accidents already. For the negative binomial distribution this is easily seen to be of the form $a + bk$. Thus the probability per unit of time of incurring an accident when k accidents have already been incurred is also of this form. Thus we see clearly why McKendrick's approach or the modern stochastic process approach also leads to the negative binomial in this case. Further, it is also true that if the classical model of accident proneness is assumed, with a Poisson distribution among persons of the same susceptibility and a Type III distribution of susceptibility, then the probability that a person who has incurred k accidents, but is otherwise selected at random, will incur another is also of the form $a + bk$. Thus we see how intimately the classical approach and the stochastic process approach to the negative binomial distribution are related. Nevertheless we must always remember, as Kerrich has pointed out, that the converse of this proposition is not true. The probability of sustaining another accident might be of the form $a + bk$, but the classical model might be entirely inappropriate.

Mr. E. D. VAN REST (in seconding the vote of thanks): I join with Dr. Irwin in congratulating not only the author of the paper but also Dr. Armitage for the way he has presented it. He has taken us with great smoothness and conciseness through what looked to be a formidable paper.

Most of us would have been prepared to accept the idea of accident proneness before we read this paper, and the author has, very usefully, warned us against the acceptance of certain preconceived ideas without more evidence. There is a general prejudice against preconceived ideas, but the statistician should know as well as anyone that they are the steps by which we advance in knowledge. Provided we do not too hurriedly and without testing make the ascent to the next step we are justified in laying down any number of such hypothetical stones.

We have in this paper a magnificent expression of the detached scientific spirit. The author has not hesitated, where the results of his analyses are inconclusive, and where the preconceived ideas have not been borne out by the data, to say so, and he has disposed of a number of ideas put forward by other authors.

The inconclusive nature of much of the analysis, not only in this paper but in others, is rather a reflection on our own ability. It is now over thirty years since Greenwood and Woods, Yule, and Student published their papers which brought in this new idea of the negative binomial. Yet we seem to have made little advance in our knowledge of accident causation. I cannot avoid the conclusion that we need some radically different approach.

I am supported in that view when I look at Table 8 and realize that the author is seeking a possible difference between two forms of distribution which are nearly alike. Of 182 men observed only 68 suffered more than one accident, and it is these small classes which are called on to demon-

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strate the difference. I am well aware that in the test used all the classes contribute to the statistic used, but it is these upper tail classes which would contribute most if there were a real difference.

I would make two suggestions. First, that the use of minor or near accidents is not always open to the objections the author has raised, and we should be on the look-out to enlarge our own experience in this way. It is difficult to imagine, for example, that the circumstances which lead to the collision of two cars are essentially different when one or more passengers are seriously hurt from when they are not. There are certainly difficulties about reporting but these are not always present.

My second suggestion, also to enlarge experience, is prompted by Dr. Adelstein's use of a fairly closed group under fairly homogeneous conditions. I think these restrictions are valuable at this stage. Could we not go further still? I have seen in factories operators attending banks of machines, all performing the same task thousands of times a day and subject to minor accidents, all of which with the supervision available could be accurately recorded. Such a group would remain closed for a long experience compared with many.

With this enlarged experience on a constant group which is probably available for measurement of other attributes a test might be available which is more sensitive than the comparison of ordinary and modified binomial distributions. The group studied could be divided according to various measurable attributes suggested perhaps by previous studies, and the parts of the group tested against one another for the simple frequency of incidence (average number per person) of accidents. Thus the attributes instead of being called on to modify a distribution to demonstrate their effect would modify the means of separate classes.

Whether this last method is used or not the larger bodies of data obtained by the two suggestions would enable us to try out the tools, the old ones and perhaps some new ones, so that they could be applied with more confidence to the more difficult, uncontrolled situations.

The vote of thanks was put to the meeting and carried unanimously.

Dr. F. GARWOOD said he would like to compare some of the problems which arose in investigating road accident proneness with the problems described in the paper. In most road accidents in public places members of the public, police and insurance companies were concerned and all required information, and it was generally more difficult to get precise information about such accidents than it was about accidents in a marshalling yard which was presumably not open to the public and did not involve the public in any way. There were classification problems and sometimes unusual events such as vehicles catching fire which resulted in personal injury and hospital treatment. That type of difficulty was comparatively rare, but difficulties of "degree" were probably more serious, e.g., whether injuries were serious or slight, or whether a slight injury should be recorded at all.

The statistics maintained by transport organizations included numerous accidents not involving personal injury, though many of them resulted in considerable damage and were serious from an economic point of view. Authorities varied in their lower limit as to what constituted accidents, and also to what extent blameworthiness should be taken into account.

If more trivial accidents were to be recorded there would be an inevitable tendency for drivers to vary in their standard of reporting, and that might well be correlated with psychological characteristics. It had been said that drivers with a high intelligence quotient had a lower accident rate because they could tell a good story and make the accident appear a minor one or the fault of the other fellow.

For employed drivers—that is to say, not members of the general public—the question of selection was more an initial one by the employer, and, of course, in some cases final rejection. There was less self-selection than with a dangerous occupation. A bus company or other employer would be concerned to employ trained drivers of a high standard and with experience. They would therefore employ a set of drivers whose intrinsic accident proneness would be lower on the average than that of the general population. Such a body of men operating under fairly uniform conditions would offer some hope of correlating accident rate with performance in tests, as in the case of bus drivers tested by Farmer and Chambers. These tests might supplement the selection process used by the managers, but could not replace it. They would improve the method of getting the cream of drivers, but the country as a whole could not or would not use the "cream", it must take the general bulk of drivers. The national problem was rather at the bottom of the "churn". A better sieve was needed to make sure that the dirt did not get in, but this sieve could not be constructed from the regression relationships which might be ascertained from the "cream"; because quite different relationships might exist in the bulk. The sieving process must be widened to take some account of those personal characteristics allied to experience, training, temperament, etc., which were the basis of the selection of the "cream".

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Mr. van Rest had mentioned minor accidents. He would add that personal injury accidents which included all slight injuries were very rare on the average per driver although the national total was large. In 1949 there were roughly 6 million driving licences current throughout the year and about 160,000 mechanically propelled vehicles were involved in personal accidents per year, which amounted to one accident per 37 drivers annually—a very low rate. Experience in one particular county police force showed that about 2·4 vehicles were involved in all accidents for every one vehicle involved in personal injury. Therefore if all reported accidents were included the rate would be about one accident in 15 drivers a year. The figure of 2·4 excluded accidents involving injury only to dogs, of which there were a large number.

Lastly, it was of interest to quote an accident distribution which the Chief Constable of a particular town had supplied to the Road Research Laboratory. The number of persons involved during three years in accidents reported to the police were as follows:

Number of Accidents	*Number of Persons*
1	3,980
2	313
3	75
4	30
5	16
6	6
7	2
10	1

This showed that it was practicable to obtain these statistics although the interpretation of them was very difficult.

Colonel G. R. S. Wilson thanked the Society for inviting him to take part in the discussion. The subject was one which certainly touched the Railway Inspectorate at the Ministry of Transport.

There they had a Senior Railway Employment Inspector, under whose leadership three others were concerned with the safety of railway servants. He worked under the speaker's general direction as Chief Inspecting Officer. The Inspectorate had been concerned with the safety of the travelling public since 1840. Each year's record was published in an annual report on railway accidents, which included fairly full statistical tables, or perhaps he should say tables of figures, and be careful not to use the word "statistical" too loosely. Every injury involving absence from duty for three days or more was reported under statute to the Ministry of Transport. Fatalities were almost invariably made the subject of formal inquiries, and when it was thought necessary an inquiry was held in a case of injury not involving fatality. (He was not speaking of train accidents but of accidents to railway servants as they went about their work.) Recommendations were often made in the Inquiry Reports. Altogether about 300 inquiries into personnel accidents were held every year.

With the task of prevention constantly in mind the inspectors at the Ministry and the railway authorities must necessarily approach accidents to railway staff from a different angle from that set out in the present paper. They had to concentrate more on the hazards, technical and otherwise, which might lead to accidents, and had no opportunity to pay so much attention to strictly personal factors, with two important exceptions : obedience to railway rules, many of which were made solely for the safety of the men, and self-discipline in the exercise of care.

This touched very much on the subject of proneness, but they had very few details about the individual's age, experience or state of health, nor did they know how long he had been away from duty as a result of injury, nor whether a particular shunter had had a previous accident last year or the year before. All this, however, would go on his personal record kept by the railway authorities. On the question of health all he could say was that if a man was off colour, even from a simple cause, he was likely to be less alert and therefore more liable to accident.

The time a man had been on duty was always stated in the accident report. The practice dated from the days when excessive hours were worked and had to be watched; that seldom happened today but it might well be that a man was less alert towards the end of his normal 8-hour shift.

The statistics available to him referred to shunting accidents in which other grades besides shunters might be included. Conversely, the figures for accidents to shunters included any personal injury sustained by a shunter on railway premises, sometimes quite unconnected with shunting.

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Accidents to railwaymen were divided into two classes—movement and non-movement. Movement accidents were all those connected with the movement of railway vehicles; "non-movement" were other types of accident which might occur on railway premises.

Railway shunting, as Dr. Adelstein had said, was a fairly hazardous occupation, but so also was a large amount of other work carried on on railways where trains, engines and vehicles were constantly moving about, often at a high speed.

In shunting accidents on British Railways in 1950 there were 33 fatalities, 328 cases of serious injury, and 704 cases of slight injury, or 1,065 casualties in all. The shunting staff proper was about 19,000, but there was also a large proportion of other men who performed shunting duties. The 64,000 track maintenance men suffered 58 fatalities and 40 injuries, or 98 casualties in all. Of about 300,000 outdoor staff on British Railways, 179 were killed in movement accidents of all kinds, 759 seriously injured and 1,604 slightly injured, or 2,542 casualties in all.

It seemed therefore that an individual railwayman could expect to work for about 118 years without being involved in a movement accident, but if non-movement accidents were included, in which there were very few fatalities but a much larger number of minor injuries, he could expect to have a reportable accident about once every 18 years. The number of non-movement minor accidents had risen appreciably since pre-war days. This was not necessarily because there had been more accidents. It might well be that, from various causes, there was more tendency to stay away from work for a slight injury.

As in South Africa, it was found that of shunting accidents as a whole, coupling accidents formed the largest single group. In 1950 there were 370 coupling accidents, or nearly 35 per cent. of the total of 1,065. The actual number of coupling *fatalities* was only 12, with 19,000 shunters at work. Coupling fatalities were very much lower on British railways than in other European countries. This was because 90 per cent. of their million wagons had plain three-link couplings which could be dealt with by a coupling pole without the men having to go between the wagons. More shunters came to grief when they coupled and uncoupled corridor coaches for, contrary to rules, they were still inclined to remain between gangways during movement. About 6,000 of our coaches had automatic couplers, and the number was steadily increasing. During the transition period, especially, automatic couplers had risks of their own. Coupling accidents might increase in the future with the steady increase of power brakes and screw couplings on goods vehicles.

Speaking more generally, one must not attach too much importance to the *results* of an accident. It was largely fortuitous when a man fell or slipped while running alongside a wagon and braking it. But the author made the point, very properly, that the *possible consequences* of an accident might affect the amount of care taken by the man to avoid it. He himself knew that when walking about the track, with the ordinary liability to slip or stumble, he was extremely careful not to knock up against the live conductor rail.

There seemed to be a little hesitation in the paper in accounting for more accidents during the winter. This might be due to the comparatively mild winters in South Africa. In this country accidents to staff always increased in winter, but there was no difficulty in suggesting the cause. Snow, frost, fog and heavy clothing were obvious handicaps to safe working on the railway. The accident rate variation over the hours of the day was difficult to determine because the traffic was so variable. The incidence of accidents must bear some relation to the traffic output, and this might account for the tendency for accidents to be less frequent at night, though one might expect the opposite. Flood lighting was not altogether satisfactory because of the intensity of the shadows, and more diffused lighting was now taking its place. Shunting accidents had not increased during the "black-out" as had been expected, probably because shunters depended largely on their hand lamps.

The effect of age and experience was difficult to separate. Young men were liable to take risks, but their youthfulness often enabled them to get away with it. In middle age a man was wiser and more mature, and old age—for railway workers—was 55–65. Many of these older and experienced men came to grief, but whether from declining alertness of mind or body or familiarity with the task it was difficult to say. It was probably a little of both. Experience was probably a more important consideration than age. At whatever age a man started his railway career he had to get over his inexperience. He then went through a fairly safe stage until familiarity perhaps began to take its toll. He was not able to quote figures, but these were general impressions after some fifty years' experience.

The safety of railway employment in this country compared well with the record of others, and had steadily improved during the last thirty years. This might be due, in part, to better general education, but credit must be given to the railway authorities and to the trade unions for safety instruction, with particular emphasis on the hazards inherent in the various types of work. The number of accidents, however, was far too high when it was remembered that most of them

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were avoidable if the men could be prevailed upon to exercise more care and observe the rules. No fewer than 32 track maintenance men last year moved aside from a train which was passing and allowed themselves to be caught by another on an adjacent line. This was against the rules, but one would hardly think that any rule was needed to avoid so obvious a risk.

In general, however, it was *not* true that there were a careless lot of men on the railways. Many of their accidents arose from enthusiasm and concentration on the work. They momentarily lost the sense of their own safety.

This scientific analysis of proneness was quite a new concept to him. On the railways it received attention in quite a different way. If a man was responsible for an accident to himself or to a train it was marked on his record, and disciplinary action might be taken by the railway authorities; if he were involved in too many accidents he might be put on different work.

Mr. J. W. WHITFIELD said that he was interested in this paper as he had worked with accident data for several years. There were some points on which he wished to comment, partly on psychological and partly on statistical grounds.

The emphasis laid in the paper on the difference between the tendency to report accidents and the tendency to have accidents was important, but there was no logical way out of the problem. If accidents were defined as incidents causing injury giving rise to absence, there probably existed a differential tendency to stay off work, and if one went the whole way to the only real criterion —a fatality—multiple occurrences could not be considered. In practice this problem was not so real; the important features of an accident to industry and to the individual were the sequelae, namely, disablement and/or absence from normal work, and it did not matter very much whether these could be attributed solely to the injury or partly to hypochondriasis.

The problem of equal exposure to risk was much more difficult. He wished to know whether the author found any significant differences between shunting yards.

He did not share the author's view that "there does not appear to be any special reason why one type of buffer is mentioned rather than another". As only 37 per cent. of the reports specified the type of buffer involved it seemed likely that this information was given only when the reporting officer regarded it as important. The apparent relationship could occur if some reporting officers *thought* that two different types of buffer were a coupling hazard.

The effect of self-selection on observations showing the relation of experience to accident liability was important and was well brought out in Fig. 9. A similar effect had been noted with shunters in this country; those who subsequently accepted promotion within shunting work showed a rapid drop in accident liability with experience, whereas those who subsequently chose another line of promotion showed no such improvement during their work as shunters.

On the criticism of the concept of "accident proneness" as a personal characteristic he had little to say except that there was evidence now which suggested that it was not as simple as was first assumed. The failure on the part of an individual, resulting in an accident, could be attributed either to perceptual failure—i.e., failure to recognize the hazard or to anticipate danger—or to response failure. It did not therefore follow that accident proneness in one situation would be associated with accident proneness in another. The association depended on the relative perceptual or response demands of the situations. Any statement on the relation of these types of persistent failure to temperament was largely conjecture based on psychiatric theory.

He had been particularly interested in Tables 5–7, which purported to show the fittingness of the Poisson distribution. In all three years the observed variance was less than the observed mean, which was somewhat unusual. If the χ^2 were combined there was a probability between ·05 and ·02, with the departure from the Poisson going in the unexpected direction. He suggested that this was due to an effect of absence after accident, reducing the exposure and hence the risk of those who sustained an accident. The observation period of a year was not long enough to allow the "tail" to grow. Such effects of absence were the main reason why other workers had used minor injury data.

Observations from British railways agreed very closely with those given in Table 15. There was no relation between accidents and mishaps—"mishaps" meaning accidents in which no personal injury was sustained. χ^2 for a contingency table was 4·75 with 10 *df* P of order ·90. This might represent a choice: Did the individual risk an accident to avoid a mishap and vice versa.

Table 18A, B and C showed the effect of removing those with highest accident rate after the first year. Here again the peculiarity of a single year's record was seen. The mean number of accidents per man for the first year was 0·640, and the variance was 0·579. Thus there was no evidence on which to pick out the most accident-prone men. By analogy, this was rather like using a fractionating column for five minutes and subsequently finding no change in the composition of the liquid underneath.

Later in the paper there was some reference to some work which Archibald and he carried out

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in 1947 in studying the repetition of accidents. In many ways he would like to disown this approach. It had its descriptive value, but χ^2 strictly ought not to be applied when the pairs were not independent, i.e., when three pairs were made out of three cases. Strictly, pairs should be treated as pairs, threes as threes, and so on.

The author had shown very clearly the practical and theoretical difficulties which surrounded the problem of accident proneness.

Mr. MANNING said that the author had rightly stressed the fact that for an infinitely variable human quality such as accident proneness a completely homogeneous population was unthinkable. But although they might feel intuitively that differences in "accident proneness" must exist, they did not as yet know whether proneness was a quality which could be expressed in terms of a single parameter, or whether two or more numbers were necessary to define a person's accident proneness.

The best known single parameter hypothesis was that which supposed that accident proneness could be treated as the parameter of a Poisson distribution. This hypothesis could be tested in the following way: Suppose a population be observed for a certain time and that each person could be characterized by a non-negative number λ, which was the expectation of the number of accidents sustained by him in the observation period. There was no need to assume that all the members of the population had the same exposure to risk; λ could be considered as the resultant of proneness and exposure. Then, on the Poisson hypothesis, the probability that a person would have i accidents was $e^{-\lambda}\lambda^i/i!$, and if the values of λ in the population had the distribution function $F(\lambda)$ the expectation of the fraction of the population having exactly i accidents was

$$a_i = \int e^{-\lambda}\lambda^i/i!\,dF(\lambda).$$

By applying Liapounoff's inequalities it could be shown that

$$a_1/a_0 \leqslant 2a_2/a_1 \leqslant 3a_3/a_2 \leqslant \ldots$$

If the equality signs held, the a_i formed a Poisson distribution and the λ-distribution was concentrated at a single point. Otherwise the inequality signs must be taken. These inequalities expressed the idea that the distribution of accidents must not tail off faster than a Poisson, and must not terminate abruptly.

There were many other inequalities which could be derived from the above set, of which one of the more useful was $a_1/a_0 \leqslant \log_e 1/a_0$. Another corollary was the familiar result that the variance of the accident distribution was not less than the mean.

As an example of the application of these inequalities he had combined the author's Tables 5–7 to obtain this distribution:

First Year of Shunting. Age 21–35 Years

No. of Accidents (i)	*No. of Men* (n_i)	in_i/n_{i-1}
0	281	—
1	202	0·719
2	62	0·614
3	6	0·344
4	0	
5	0	
6	1	
	552	

It would be seen that the ratios in the last column decreased instead of increasing; but in fact the decrease was found to be not statistically significant when the ratios were compared with their approximate standard errors. Thus in this case they had not disproved the Poisson hypothesis (as indeed the author himself had shown in his discussion of his Tables 5–7). The decrease in the ratio $i\,n_i/n_{i-1}$ was reflected in the fact that the number of shunters with three or more accidents was below expectation in all three tables.

The above test had been applied to a number of accident distributions, and two or three of these had turned out to be incompatible with the Poisson hypothesis. One of these was the distribution of accidents to New York drivers, quoted by Smeed as group D in the paper previously

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referred to by the present author. This distribution seemed to indicate that, after having one accident, a driver either reduced his exposure to risk or became less susceptible to accidents, or became less conscientious in reporting his accidents.

Most of the work he had described was carried out as part of the Road Research programme when he was on the staff of the Road Research Laboratory.

The following contributions were received in writing:

Mr. E. G. CHAMBERS: I am grateful to Dr. Adelstein for stressing the fact that the connotation of the term "accident proneness" has been changed since Farmer and I first defined it, and in so far as his criticisms are directed against the popular use of the term I am in full agreement with him. However, when he attempts to explain away the quite large body of work done by our predecessors and ourselves I am much less happy. The fact that his findings do not altogether agree with Newbold's and ours does not necessarily mean that we are wrong and he is right. For example, he claims that the factor of accident proneness, even when it is present, plays only a small part in the occurrence of accidents, and from this he concludes that accident proneness is of small practical importance. Now we agree with his claim—we have never suggested otherwise—but we cannot agree with his conclusion. If only, say, 5 per cent. of accidents could be prevented by eliminating certain highly prone individuals, surely this would be worth doing? Dr. Adelstein's own figures about the cost of accidents and the loss of man-days of work indicate as much. It does not seem to be a very sound argument to say that because chance factors play a predominantly large part, other small factors should be neglected, particularly as Dr. Adelstein does not indicate how these chance factors may be prevented from operating. Perhaps my chief criticism of Dr. Adelstein's painstaking paper is that, imposing as it appears at first sight, his body of data is really not large, and it is drawn from a selected and rather unusual field of observation. Although from the records of 11 years he has quite a large number of accidents to deal with, the actual accident rate is small; Fig. 10 shows it to be only one-fifth of an accident per man per year. This does not give much scope for the admittedly small factor of accident proneness to manifest itself except over a lengthy period of observation. In our report on accident proneness among motor drivers Farmer and I indicated that usually we could not demonstrate the operation of accident proneness when the annual average accident rate was less than 3 and the period of exposure less than 4 years. Further, the type of accident sustained by shunters tends to be rather serious in nature. It may well be, therefore, that having incurred one accident a person tends to exercise more care and so tends to avoid future accidents. In other words, through experience a person may become less accident prone. Dr. Adelstein does in fact suggest that this may be the case. The opposite tendency, that of a person being rendered "nervous" by having incurred an accident and so becoming more accident prone, might also obtain. If both tendencies are present, it is most unlikely that a mathematical model could be fitted to the data unless some other information, such as that obtainable by psychological testing, were available in order to segregate the two types of individual. In point of fact, only 122 of the shunters survived the whole 11 years of observation, and several arguments are based on the records of these men. Surely it is a legitimate deduction to say that if these persons could survive 11 years in a very hazardous occupation they must have a very low degree of accident proneness? Even so, their records do indicate the operation of proneness to some extent. At the foot of Table 3 Dr. Adelstein states that 9 shunters died and 211 were permanently disabled. This is a total of 220 persons out of a population of 1,442, or almost one sixth. Dr. Adelstein does not appear to envisage the possibility that these 220 persons might include the most highly accident-prone individuals in the group, and that their disablement prevented their proneness from manifesting itself.

One further small point is that the division of shunters' accidents into "major" and "minor" according to the number of days lost, taking the dividing line at 6 days, is quite arbitrary. The period of exposure, as shown in Table 14, is 5 years, so that since Dr. Adelstein failed to find evidence of accident proneness in a period less than 11 years, it is not surprising that there is no correlation between major and minor accidents so defined. Even so, Table 14 shows quite a nice linear regression, the mean "minor" injury rates for the different "major" injury groups being 0·46, 0·55, 0·63 and 0·71 respectively. The last figure combines the 3 and 4 "major" injury groups. In summary, I should say that while Dr. Adelstein's conclusions may be justified as regards his own data, they do not necessarily invalidate the conclusions of other workers using different types of data.

Professor M. S. BARTLETT: I am sorry to have missed what I am sure will be a stimulating meeting, and would like to express my appreciation of the paper, with which I would also associate the recent paper by Arbous and Kerrich in *Biometrics*. My further comment refers to a theoretical

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point, in the sampling theory of χ^2, which is unimportant in the present context but which I think should be clarified; I am not aware that it has previously been discussed.*

With the compound distributions corresponding to the hypothesis of heterogeneity in accident-proneness more than one sampling interpretation is possible. We may consider the accidents experienced by chance either (i) by the particular set of operatives for whom we have data, or (ii) by a random set of operatives varying from sample to sample. Only with the latter interpretation (which on reflection seems to me to be the more reasonable one in the present problem) is the standard χ^2 theory used in the paper strictly valid. In any case, while the expected value of χ^2 would be depressed on the first interpretation, the effect would be too small to affect any conclusions (for example, there would be a reduction of about $\frac{1}{4}$ in the expected value of the total χ^2 in the case of Table 10*c*).

But in other contexts it is possible that not only would the first interpretation be more relevant, but also the effect less trivial. Thus the negative binomial distribution with extreme heterogeneity gives rise to the logarithmic distribution, which has been found to fit biological data such as the observed numbers of species of moths caught in a light-trap. Here it may sometimes be more reasonable to consider the different species being sampled as given, and the reduction in the expected value of χ^2 can reach $\frac{1}{4}$ for the first observable class (the number of species for which one individual is caught) alone, with slowly diminishing reductions for the further classes.

Dr. ADELSTEIN subsequently replied in writing as follows:

I should like to thank the speakers for their appreciations and suggestions. On the point made by Dr. Irwin about the dice-throwing analogy, Greenwood and Woods used the dice-throwing analogy in support of their contention that the outcome of an accident did not depend on the circumstances preceding it, and that it followed that minor accidents could be used as the indicators for major accidents. Throwing a six represented, say, a major injury, and one could not influence the number of sixes thrown by the stakes on the game. The example was used when some degree of proneness was postulated, and it was to suggest that the degree of proneness was consistent when different degrees of injury were considered, i.e., minor and major.

In reply to a point by Mr. van Rest, it seems reasonable to think that a driver may vary his care and speed according to whether he has his family with him, whether his brakes are in order, and so on. In many cases, and where the accident is due to "chance", the result may be largely fortuitous. The suggestion about studying closed groups with accurate, objective recording of accidents is excellent, but the practical difficulties are very real. The labour turnover and differential reporting of accidents are two difficulties, among others.

Dr. Garwood's remarks were most interesting, and emphasized the many difficulties encountered when studying accident statistics.

Among the very interesting remarks of Colonel Wilson, there is the suggestion, again, that "one must not attach too much importance to the *results* of an accident". Although this idea seems attractive it is necessary to repeat that the available evidence does not support it. There is also the tendency to blame men for being careless and for failing to observe the rules. This attitude suggests that dangerous occupations can be made safe by regulations. It ignores the fact that humans behave as humans, and not in some ideal way existing only in the imagination of the maker of the rules.

Dr. Whitfield's remarks were stimulating and instructive. On the point about the difference between the tendency to report accidents and the tendency to have accidents, it did seem possible to lay down operational definitions of the injury which could be objectively assessed by, say, a doctor, especially if rather more serious injuries were used. Furthermore, it seems to be important to distinguish between hypochondriasis (and malingering) and real injury, when it comes to the question of understanding methods of prevention. Differences between shunting yards were not comprehensively studied because of the difficulties encountered in equalizing factors such as age and experience. It was possible that a selective process took place when the type of buffer was mentioned in an accident report, but there was no knowledge of the exact way in which it operated.

Mr. Manning's remarks were most interesting, and Professor Bartlett's discussion of χ^2 very instructive.

It is gratifying to have the observations of E. G. Chambers, who has done so much basic work on this subject. If, when accident proneness is shown to play a part in a specific situation, the accident prone could be pre-determined, this would be very useful. But, so far, no practical method has been shown. "Chance" factors take place in the environment created by the inter-

* Cf., however, a similar discussion in relation to errors of *estimation* by F. J. Anscombe (*Biometrika*, 37 (1950), p. 378).

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action of the man and the working conditions. All safety measures directed towards the machinery or the man such as training, health, etc., will diminish the "chance" factors. It is obvious that if the accidents studied are serious the rate will be low. If a person learns to avoid an accident by having one (or the opposite tendency occurs) this would alter the concept of proneness as accepted at present. It must be pointed out that only 122 "survived" the eleven years, not because of accidents, but chiefly from unrelated factors such as resignations and promotion. Permanent disablement is often of a minor nature, such as the loss of the tip of a finger, and does not prevent the man from working. In conclusion I would add that I have often emphasized the point that different kinds of data might well yield different results.

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

John Howard Champness.
Robert Frederick Ellis.
John Walter Gibson.
Mohammed Yahya Khan.
Arthur Linder.
Andrew Logan.
Denys John Page.
Wilfred John Parker.
Hubert Phillips.
Joyce Doreen Svenson.
Hiang-Yong Tan.
Geoffrey Howell Thomas.
Edwin Arthur Thorne.
Henry Edward Titchmarsh.
Fui-Chang Yap.

Corporate Representative

Leslie Robert Henry Jebson *representing* British Celanese, Ltd.

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Quota Sampling

By C. A. Moser

(Division of Research Techniques, London School of Economics and Political Science)

Part I.—Introduction

Random Sampling and Quota Sampling

In the sampling of human populations the selection of the final sample units is usually carried out by one of two methods: random sampling or quota sampling. Of the former there are many variants, ranging from pure random selection (by random numbers or the lottery method) to more or less systematic selection from some complete record of the population. Area sampling, predominantly used in the United States, is a form of random sampling. Whatever the details of the sampling designs or frames employed, one characteristic is—or should be—common to all random sampling. The selection of the sample units is carried out by some impersonal (strictly determined) method and is uninfluenced by human choice. That is to say, the interviewers are not allowed any freedom in deciding which members of the population shall be included in the sample. This independence of selection from human judgment is a prerequisite for ensuring that every member of the population shall have a known chance of being included in the sample—which is what we mean by randomness.

Quota sampling differs from random sampling in several minor ways, but the fundamental difference is that, once the general breakdown of the sample is decided (e.g., how many men and women, how many people in each age-group it is to include) and the quota assignments allocated to each interviewer, the choice of the *actual* sample units to fit into this framework is left to the interviewer.

Much discussion has centred around the merits of the two techniques. Some experts believe the quota method to be so unreliable and prone to bias as to be almost worthless; others think that, although not as accurate as random sampling, quota sampling can be used safely on some types of inquiry; while some believe that, if careful instructions are given and if sufficient constraints are imposed on the freedom of the interviewer, quota sampling can be made highly reliable, and that the heavy extra cost of random sampling does not result in a sufficient increase in accuracy to be worth while. In general, academic statisticians have criticized the method for its theoretical weakness, while market research workers have defended it for its cheapness and ease of practical application.

This issue is not by any means the most important problem in survey methodology, nor even perhaps in the more narrow field of sampling. Yet the fact is that the controversy has continued —most fiercely in the United States—for many years, largely unaided by any experimental evidence, and that the argument is still conducted mainly on the basis of prejudice and untested assumptions. There is no clear-cut answer to the problem, in the sense that either method could be shown to be preferable in all circumstances. There are some types of survey on which nobody would suggest using a quota sample, while there are others on which random sampling may be impracticable. Still, there remains a large field on which either method *could* be used, and research is required to throw factual light on the merits of both techniques. It therefore seemed worth while to embark on a programme of reasearch into quota sampling, in the hope that the results will be of value and interest both to statisticians generally and to market research practitioners. The present report represents the first, preliminary, stage in the research. It consists of three parts. The remainder of the present part is devoted to an examination of the usual cases for and against quota sampling, followed by a statement of the general aims of this research programme. The second and major part is a description of current quota sampling practice in this country.

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The final part then attempts to suggest which are the aspects of quota sampling on which the research should concentrate.

The Usual Case Against Quota Sampling

The selection of the final sample units by the quota method is usually criticized on the following grounds:

(*a*) The use of random selection—implying that the probability of inclusion of population units in the sample is known—makes it possible to attach standard errors to the sample estimates. Quota sampling does not meet the basic requirement of randomness, and it is thus not legitimate, from a theoretical viewpoint, to calculate standard errors for quota sample results.

(*b*) Quota samplers invariably attempt, as one of their controls, an economic or social breakdown of the sample. Two objections can be made against this type of control. In the first place, it is inevitably based on a hazardous statistical foundation. There are no official or other really reliable figures of social or economic classes. In the second place, these controls are inevitably defined in vague terms. The interviewer uses his or her judgment in deciding to which "class" the respondent belongs, so that there is room for bias.

(*c*) Bias may be introduced because, *within* the quotas, interviewers may not secure a representative sample of respondents. For instance, although the required number of working-class persons is included in the sample, interviewers may have chosen people towards the upper levels of the working class. Or, again, the top age-group of 65 and over may be filled by persons of 65 and 66, so that the very old people are under-represented. Similarly, the sample might under-represent housewives with outside jobs or with very large families. In all such cases a biased sample would result.

These are hypothetical examples of what is the crucial problem of quota sampling. Given that all the quotas are correctly and honestly filled—i.e., that every sample unit is in the cell to which it properly belongs—is the spread within the cells such that an unbiased sample emerges? In other words, can human choice do what is expected of random selection?

The extreme form of the unrepresentativeness argument is that, even if the quota sample is correct on the controls *and* most of the uncontrolled variables as well, it may still be unrepresentative with regard to the variable under study.

(*d*) Bias may arise through the peculiarity of the interview situation. In so far as people are interviewed in the streets or in their offices or factories, biased information may be obtained.

(*e*) Objection is sometimes made to quota sampling, not merely because the interviewer has too much freedom in choosing respondents, but because the method allows altogether too little office control of the fieldstaff. It is more difficult to check on the honesty of interviewers in the case of quota than in that of random sampling; and the former method probably offers more temptations to the unscrupulous interviewer. For instance, investigators may place respondents in the cells where cases are needed or difficult to find, rather than in those to which they really belong. This may apply particularly with vague controls, such as "social class".

The Usual Case for Quota Sampling

We now turn to the arguments usually put forward in favour of this method. Some of the points here are answers to the above criticisms, rather than positive advantages:

(*a*) Two points are often made in reply to the first criticism above. Firstly, it is justifiably argued that random samples as selected and as achieved are two different things. In practice, some of the original sample is not obtained on account of refusals and non-contacts. In fact, random sampling is not free from bias, and the standard errors are attached to what may, in fact, be a biased final sample. Secondly, it is argued that sampling errors are of comparatively small importance as against the very considerable and intractable non-sampling errors which arise in the collection of the data. Consequently, to criticize quota sampling on the grounds that sampling errors cannot be calculated is to concentrate on a relatively minor issue. (The main point of that criticism still stands, namely that in quota sampling, owing to the absence of the condition of randomness, one does not know the accuracy of any particular sample.)

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(*b*) The main argument for quota sampling is that it is very cheap. This cheapness is due largely to the much lower travelling costs and to the lack of call-backs. It is difficult to obtain accurate figures, but it is probable that the average random interview in this country costs about twice as much as a quota one.

(*c*) Quota sampling is much easier from an administrative viewpoint. There is no need to go through the tedious stage of drawing the sample; no problems of non-contacts, call-backs, or substitute lists; no *apparent* problem of refusals; no need, unless this is specially required, to do much evening interviewing or to send field-workers to out-of-the-way areas. Responsibility for the sample is largely transferred to the individual interviewer, and the office burden is consequently lightened. Interviewers with experience of random and quota sampling usually prefer the more elastic, less controlled and less tiring quota method.

(*d*) If the field-work on a survey has to be completed within a very short time—say, one day—quota sampling may be the only feasible method.

(*e*) In partial answer to criticism (*b*) above, it is said that only a very few and extremely broad social groups are used, and that disagreement about the class of a respondent would be rare.

(*f*) Quota samplers generally believe that instructions to and constraints on interviewers are sufficient to guard against the main dangers of bias outlined in (*c*) above, but they mostly agree that this is a matter of belief rather than fact.

(*g*) Finally, it is worth pointing out that quota sampling is independent of the existence of lists. As long as good lists—suitable for sampling individuals and households—are available, as is the case in this country, this is not a point of substance. But if, for instance, the National Register were to be withdrawn or to lose its present accuracy, there would then remain only the alternatives of either using one of the other, and less satisfactory, lists; of using area sampling; or of using quota sampling—if this technique has been shown to be of any reliability. (It is worth noting that the National Register is not in fact available to market research organizations for sampling purposes. For national list samples market research bodies would have to depend largely on the Electoral Roll or the Rating List.)

(*h*) Quota sampling is also defended on the grounds that, although the sample may be biased with regard to certain characteristics, it may be quite satisfactory for others.

The main arguments against and for quota sampling have been listed. All of them are to some extent controversial. We are entering on this research with open minds, hoping that at the end at least some of the pros and cons may cease to be matters of conjecture.

The General Aims of the Research

Our main aim is to find out what types of bias, if any, are inherent in the method of quota sampling, and to what extent these biases can be eliminated altogether or brought under control by careful training or by the introduction of further constraints on the freedom of the interviewers in selecting the sample. In other words, we should like to know not merely how accurate quota sampling is, but also how accurate it can be made by the use of various refinements.

In the long run we should like to accumulate data to indicate when particular biases, if they are found to be uncontrollable, are important, and when they can safely be ignored. It is often said that quota sampling is quite good enough for some purposes. We want, if possible, to give this statement greater precision.

In short, this research is aimed more at the future than at the present. We felt very strongly, however, that any actual experimentation should be preceded by a study of present-day quota sampling practice. Only in this way can one decide which are the critical aspects of the method needing experimental investigation. Four leading market research organizations in this country —B.B.C. Audience Research, British Institute of Public Opinion, British Market Research Bureau and Research Services, Ltd.—were asked a number of questions regarding their sampling procedures and have given us every possible co-operation. In addition to discussion with their sampling experts, it has been possible to talk to the field supervisors about actual field practice. We are most grateful for the help given us by the organizations. The information received is summarized and discussed in Part II below. It is desirable to retain anonymity, and particulars quoted will not be identified with any one organization by name. (The letters A, B, C and D are used—not, incidentally, in the above order of organizations.)

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PART II.—CURRENT QUOTA SAMPLING PRACTICE

1. *The Quota Controls**

1.1. *The Standard Controls*

The standard controls used differ little from one organization to another. Three are used in every case: sex, age, and social status (this last is alternatively called income grade, economic group or socio-economic group). The age grouping varies in broadness, anything from three to six groups being distinguished. (There is some variation of practice regarding the age question; in some organizations interviewers ask for the actual age, while in others they are told to estimate it.)

The "social status" grouping is also broad. One organization distinguishes five, another four, and the others three groups. This control is discussed in detail below.

Organization B always uses the additional control: in employment/not in employment; while *Organization C* always imposes a further constraint by dividing women into housewives and "occupied" women.

1.2. *The Special Controls*

Many other controls are used occasionally, if a particular survey seems to require it. The following may be instanced: head/non-head of household; housewife/non-housewife; married/single. Attempts at control by occupational group are sometimes made. Two of the organizations rarely, if ever, employ controls other than the standard ones.

The important point here is that every attempt is made to keep the controls down to a minimum. The more complicated the quota scheme, the more restricted the interviewer's freedom, the more difficult her task becomes and the more costly is the whole survey. The attraction of quota sampling is its simplicity of design and execution, and there is a continued resistance to the use of additional controls, in the hope that the work of controls can be done by careful interviewer instructions.

1.3. *Statistical Basis for the Controls*

Neither age nor sex present difficulties as regards their statistical basis. The employment/not in employment control is based on published Ministry of Labour figures. The housewife/occupied woman control is based either on figures from a P.E.P. Report on the Employment of Women or on figures derived from the Social Survey's *British Household*. The statistical basis of most of the controls (social status is discussed below) is reliable as long as the figures for a single control are required. Nearly all the organizations attempt to vary their quotas regionally, and the figures, when two or three inter-related controls are used, become less well based.

1.4. "*Social Status*"

This control—under one of its various names—is used by all the organizations and is an integral part of quota sampling. Without it, quota samplers rightly feel, the method would be most precarious. It is, however, the weakest of the controls both in its statistical basis and its definition. We will now discuss the organizations separately, giving for each the most usual practice.

Organization A generally distinguishes five income grades:

A. Over £1,000 p.a.
B. £650–£1,000.
C. £400–£650.
D. £225–£400
E. Below £225.

* National quota samples, like random samples, are generally stratified by geographical region, urban/rural area and, occasionally, town size. These are not quota controls, and we are here concerned with the selection procedure *within* the primary sampling units, such as towns, etc.

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These are generally filled in the overall proportions of 5, 10, 20, 55, 10 per cent. The quotas are varied regionally. The breakdown is based on figures derived from past random surveys conducted by the organization and is revised about once a year. Occasionally a broader breakdown is used by combining A + B and D + E. The income grade refers to the head of the household; interviewers ask for occupation and take careful note of details concerning family habits, amenities, type of dwelling and so on. On the basis of this information they decide which class to place the person in. To aid them in this task, their field manual contains particulars of family habits, amenities, etc., and examples of occupations associated with each of the five grades. The interviewer asks for the *actual* income grade only in cases where she feels some doubt or difficulty in deciding on the appropriate grade.

Organization B distinguishes three social groups:

A. Upper middle class.
B. Lower middle class.
C. Working class.

The usual over-all breakdown, which is varied regionally, is 5, 20, 75 per cent. The figures are originally derived from the publication *The Home Market*, and are modified on the basis of the 1950 edition of that book and of recent Hulton surveys. The assessment is a subjective judgment of socio-economic class, and is made on the basis of the informant's occupation, manner and conversation, with the stress on occupation. In the case of housewives, however, no details of the husband's occupation are asked for, and the class assessment is to be made entirely on her manner, appearance and conversation. The manual gives examples of the sort of occupations found in each class.

Organization C distinguishes three socio-economic classes:

AB. Upper and upper middle class.
C. Middle and lower middle class.
D. Working class.

Interviews are allocated in the overall proportion of 10, 20, 70 per cent., and the breakdown is varied regionally. The figures are derived from those used in, and published at the beginning of, the Hulton Survey. Cultural rather than economic factors control the placing. Interviewers are told to classify their respondents according to their first impression of the social type and by observing their "surrounding conditions", including the type of home and the occupation. A list of occupations typical of those found in each class is given in the manual. But interviewers are told that, if the occupation and environment of a respondent do not seem to be in line with the class judged to be appropriate on the basis of his personal characteristics, etc., then the final assessment is to be made on the latter rather than on occupation and environment.

Organization D distinguishes four economic groups:

Average + : Upper class group.
Average : Upper middle class.
Average − : Lower and middle working class.
Very poor.

The usual breakdown is 5, 21, 59, 15 per cent. and is derived from figures in the pre-war *Home Market*. In assessing economic group, interviewers are told to pay attention more to occupation and general social standing than to earnings. Notes in the manual give guidance on the sorts of occupations, home amenities, and so on, to be found in each group

This summary shows that the differences are in emphasis rather than general approach. The statistical basis is, and is often admitted to be, somewhat arbitrary. Survey statisticians would be happy if they had official figures on which to base this control. However, it seems doubtful whether any significant bias is introduced by the use of a breakdown which may be slightly inaccurate. The order of magnitude of the different classes is likely to be right, and this class stratification would have to be very inaccurate to affect overall results materially. In most surveys results are not given for the whole sample but are quoted separately for the different social groups, in which case the wrong size of the groups is even less likely to matter.

Much more serious as a possible source of bias is the vagueness of definition of these controls. The main objective index available, income, is usually avoided—for obvious reasons. It is admitted

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that the class allocation is largely a matter of the interviewer's subjective judgment and that there is room for bias and differences of opinion, especially with borderline cases. This is a very weak point in quota sampling, and needs to be considered in any experimentation.

2. *The Quota Scheme*

The way in which the quota scheme is constructed constitutes an important difference between organizations. There are two alternatives; the controls may be inter-related or they may be set independently. In the case of *Organization A*, they are inter-related on nearly all surveys so that the interviewer is given a scheme of the following type:

	A			B			C			D			E		
	16–24	25–44	45 *and over*	16–24	25–44	45 *and over*	16–24	25–44	45 *and over*	16–24	25–44	45 *and over*	16–24	25–44	45 *and over*
M.															
W.															

Organization B, on the other hand, issues a totally different type of scheme:

Social Groups

A	
B	
C	

Sexes

Men	
Women	

Age Groups

16–19	
20–29	
30–49	
50+	

Employment

In employment	
Not in employment	

No attempt is made to relate the controls to each other, so that it is possible that all the "In employment" tend to be men, and "Not in employment" women, and that other controls are "paired" in a similar way. Instructions are issued to interviewers to avoid this kind of biasing relationship between controls, and the results are checked with this in view.

Organization C uses inter-related controls in the case of men and occupied women (the controls being age and socio-economic group). In the case of housewives the breakdown is by socio-economic group only.

Organization D does not inter-relate any of the controls. Interviewers are instructed to aim at a wide spread. Thus, they are told to "get the men and women spread evenly between age and economic groups".

It is difficult to assess how much is gained in accuracy and representativeness by inter-relating the controls, but there can be little doubt that it is to be preferred to the setting of independent controls. The latter may be simpler for the interviewer and less costly; but it is unlikely that, even with explicit instructions, the "pairing" effect, with its resultant bias, can be avoided. The main point in favour of independent controls is that it is easier to find an adequate statistical basis for setting marginal totals (which is all that is necessary for independent controls) than for all the cells of the quota scheme.

3. *The Filling of the Quotas*

3.1. *The Location of the Interviews*

Random sample interviews are home interviews (except in special surveys); in quota sampling, interviews may be made—unless instructions to the contrary are given—at home, in offices, factories, parks, public places or in the street. There is a good deal of variation between

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organizations in this respect, as well as between types of surveys within one organization and between interviewers on any one survey. The details below can only give a general average picture:

Organization A allows interviews to be made in all types of location. If, in a particular survey, street interviewing is to be excluded (as would be the case if a very complex questionnaire is involved), instructions to that effect are given in the job manual. Interviewers are instructed that they may interview in factories as long as permission is granted, and workers are willing—and not ordered—to be interviewed. If a particular factory is very helpful, there is nothing to stop interviewers going back in another survey. On the whole, though, investigators are told to do as much home interviewing as possible and, as a rough approximation, it may be said that two-thirds of all interviews are done at homes.

Organization B interviewers may work in the street or by calling at houses, or places of work, but most interviews are in fact of the first type. The following rough figures show this:

Proportion of Interviews Done at Homes	*Percentage of Interviewers*		
	Urban	*Rural*	*All*
All or most	11	14	12
More than half	9	17	11
Half	14	23	17
Less than half	14	21	16
Few or none	52	25	44

Organization C allows no street interviewing. Housewives are always to be interviewed at home (not in shops or queues), while others may be interviewed in offices, factories, etc. If the sample is controlled by occupational group (as is sometimes the case), all occupational interviews are to be made at the place of employment.

Organization D: On two recent, fairly typical, surveys, home interviews accounted for 36 per cent. of the total, office and factory for 9 per cent. and street and other interviews for 55 per cent.

Factory and office interviewing is allowed for the obvious reason that it catches the sort of people who tend to be missed in ordinary day-time street interviewing. Even so, it is doubtful whether a fully representative sample emerges. Quota samplers themselves have suggested that they are liable to under-represent heavy manual workers, miners, dock labourers, and that they may get too many engaged in distribution and transport, and possibly too few unoccupied women.

Supervisors indicate that—within the limits set by the quotas and the instructions—the relative amount of street/home/factory interviewing is entirely a matter of personal preference, coupled with the weather and the investigator's knowledge of the locality. Street interviewing is clearly economical of time, and the common view seems to be that, with a reasonably short questionnaire, it does not affect the quality of the interview detrimentally.

3.2. *The Spread of Interviews*

It is a common criticism of quota sampling that it is unlikely to achieve an adequate geographical spread within the areas—districts, towns, etc.—selected for sampling. This point, furthermore, is a source of worry to some market research practitioners, and various attempts are made to secure an adequate spread.

Organization A lays down instructions to the effect that a space of at least 20 houses must be left between houses in urban areas, and 15 in rural areas. Furthermore, it is suggested to interviewers that they should divide their area into as many segments as they have interviewing days and that they should tackle one segment a day. It is felt that this should be a matter for advice rather than of binding instructions. If the spread in a particular survey is of overriding importance, this organization would probably use a random sample.

Organization B has no instructions on spacing between houses, but tells its field-workers "not to go farther from your house or business than is necessary to obtain your required daily quota". It should be added that all the surveys conducted by this organization consist of one-day quotas, so that it is not feasible to attempt a wide coverage.

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Organization C instructs interviewers to spread interviews over the whole town, if possible. They are told—in the manual—that "having arrived at a street and made your first call, which should not always be the first house in it, proceed along it, leaving a space of 5 houses between each interview until you come to a left turn; then leave your first road and go along the left turn one until you come to a right turn, etc. . . . When you have started making calls in a road, do not cross to the other side except to take a left or right turn".

Organization D tells investigators to carry out the interviewing "as near to your home as is compatible with fulfilling your quotas and getting a good mixture of the local population. . . . Nothing is gained by trying to cover all parts of your area. We are anxious for your sake and our own that travelling should be reduced to an absolute minimum".

The geographical spread of quota samples is clearly a point for investigation. One wants to know whether interviewers tend always to go to a particular area, whether certain parts of a town are systematically under-represented. In making such an examination, one must naturally take a large number of quota samples. There is no reason to expect one single quota sample, any more than one random sample, to be spread over the whole area. In practice, the quota of, say, 30 interviews in a town is covered by one interviewer, working in only a small part of the town. In random sampling it is possible to select two or three wards randomly from all the wards in the town, and to confine the sampling to selected wards. If, in the quota case, there were a large number of interviewers spread over the whole town and if one or two interviewers were selected at random for one particular survey, the two ways of tackling the town would be formally equivalent.

It is, in fact, argued by at least one organization that its large turnover of interviewers serves to achieve a reasonable geographical spread of interviews in the long run. The argument is more difficult if the field staff consists of a relatively small number of persons who do the work over a long period of time, always interviewing in the same town or district.

3.3. *Timing of Interviews*

It is not possible to give general figures. *Organization D* does something like a third of its interviewing in the evening, while others do the great majority of their interviews during the day. No definite rules are imposed for the timing of interviews.

3.4. *Other Restrictions on the Filling of Quotas*

There are certain other restrictions on the filling of quotas which are worth mentioning: No organization allows more than one person to be interviewed in any one household. In addition, in *Organization A* the same person must not be included in surveys more than once a year. No definite restrictions are imposed on the numbers to be taken in any one factory, although interviewers are told to avoid taking "too many" and a check is kept on this at the office. *Organization B* does not allow any person to be interviewed more often than once in three months. (In this organization interviewers are permitted occasionally to take more than one person in a household in rural areas). *Organization C* tells interviewers that, when interviewing on industrial premises, they may take one person for every 20; and that, if there are less than 20 altogether, they may make one interview. *Organization D* does not allow more than three interviews in any one block of flats, row of houses or factory; nor may anyone be interviewed in a second survey.

4. *Field Organization*

Certain aspects of field organization are relevant to the present subject and will be discussed briefly.

4.1 *The Interviewers*

Organization A is the only one among the four which is staffed by full-time field-workers. The others employ part-time staffs with varying frequency of employment. In the case of *Organization B* a field-worker may expect an assignment perhaps once every 2 or 3 months and would then be given about 10–20 interviews a day for 2–3 weeks. These are always short interviews—lasting only about 10 minutes. Interviewers in *Organization C* work 4 days out of 5 on

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the average, and are thus virtually full-time. In *Organization D* about 250–300 out of the 700–800 interviewers in the pool are in the field at any given time and each of them would do about 15 interviews on any one survey.

It is of interest to note that, in all the organizations, the interviewers are largely local people, i.e., that they are working in the towns or, at least, districts in which they live. (In one case interviewers are instructed to avoid areas in which they are well known.)

4.2. *Training and Supervision*

All the organizations have field manuals, which include sections on the selection of the sample and quota filling, and in some cases a job manual is issued for each specific survey.

As regards selection of interviewers, one organization accepts all who apply—within reason. Many are then dismissed if their early interviewing is not up to standard. The other bodies enforce selection procedures of various types. One selects entirely by personal interview; another demands the names of two referees, whose opinions are invariably sought. All place more emphasis on success in early interviewing.

Training—some form of which is used by three of the organizations—mainly consists of supervised interviewing. In one case a fair amount of more formal training is given at the office —on sampling instructions and so on—and this is followed by two days' practice interviewing. In another, two days' trial interviewing is done and a detailed report on the performance is given to the interviewer. In the third a fortnight's supervised interviewing has to be done.

It is generally felt that one of the main values of supervision is the psychological support it gives to the field-staff. Interviewers are greatly helped in their work by the knowledge that supervisors are available to advise them, to solve any difficult problems and so on. It is difficult to assess just how valuable supervision is in this respect. Survey directors have to decide, on more or less arbitrary grounds, how much money to spend on supervision and, as a result, there is wide variation between organizations in the emphasis placed on the supervisory side of field-work.

The other side of supervision is the attempt, by checks, call-backs and occasional supervised interviewing, to prevent the lowering of interviewing standards and to deter and detect the cheat. More will be said about this in the next section.

It is widely agreed, and of considerable importance for the present research, that experience plays a very considerable part in quota completion and interviewing; that it is more important than formal training, and that it plays a greater part in quota than in random sampling.

5. *Checks*

A point of great importance is whether the honesty and accuracy of field-workers can be checked. Every organization makes attempts at checks as much in the hope of deterring the cheat as of detecting him. Some checking is possible if the respondents can be traced, and all the organizations now ask for the names and addresses of interviewees (except, in the case of one organization, on political surveys).

Organization A: Supervisors actually call back on 10 per cent. of the respondents, and this is thought to bring about "a fairly healthy respect for the sanctity of quota controls". A check is then made on whether the interview actually took place and on the accuracy of the classification data. No tabulated results of these checks are available; but, as regards the former, actual dishonesty is said to be quite rare. In the case of classification data, it is a matter of disagreement between interviewer and supervisor rather than of inaccuracy, and action is taken only if such disagreements are very frequent for one interviewer.

Organization B makes a "postcard audit" on whether the interview took place or not. For each interviewer, one day of his assignment is selected and a postcard is sent to every contact made on that day. About 65 per cent. of the cards come back, nearly all (64 per cent. of the total) saying that the interview did take place. The remainder are either not returned, or come back via the G.P.O. marked "not known" or "insufficient address". If the results seems unsatisfactory, a second day from that particular assignment is checked.

Organization C until recently recorded only the location of the interview, not the address of the respondent. Various checks are now being tried experimentally, partly attempting to

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overcome the weakness of postal checks, i.e., the usually large percentage of cards or letters which are not returned. No tabulated results are yet available.

Organization D makes a postal check on 10 per cent. of the interviews. In addition, a 100 per cent. check is made on two or three interviewers selected in turn and upon anyone whose work seems unsatisfactory. On the former a 60 per cent. return rate is usual. Occasionally someone complains that no interview was made. In such a case an explanation is asked for from the interviewer. A small proportion—perhaps 3 per cent.—is returned via the G.P.O., marked "not known" or "insufficient address". Again an explanation is demanded and is quite often satisfactory—there may have been an error in recording the address, or the contact may have moved to a new one without notifying it. In this organization the loss of interviewers through suspected "cheating", in the sense of not making an interview, is between 12 and 15 a year, which compares with the total turn-over rate of some 300.

Nobody claims a great deal for these checks. There is more faith in their psychological value in discouraging the cheat than in their power of detection. Something could be done to improve their value in this direction. Furthermore, none of these checks help in assessing the quality of the quota completion or the interviewing performance.

6. *Refusals*

It is sometimes said that quota sampling avoids the problem of refusals. This is, of course, not true. Quota sampling hides the influence of refusals, and we must try to ascertain to what extent refusals bias the samples. Unfortunately, very little information indeed is available on this in any organization.

In *Organization A* field-workers are supposed to complete forms for all unproductive interviews (this includes—and investigators are to distinguish between—refusals and contacts who were "wrong for the quota"). Few refusals (no accurate figures can be given) are found. Interviewers are asked to record the age, sex, income grade and occupation of the refusals as well as their reasons for refusing.

Organization B asks interviewers to record numbers of refusals, and estimates that about 2 per cent. of persons approached do actually refuse.

Organizations C and D ask for the numbers of refusals to be recorded on some surveys, but no tabulated findings are available.

In short, we are very much in the dark about the numbers and the characteristics of people who refuse to be interviewed.

7. *Actual Field Practice*

It would have been useful to have given an account of the way in which interviewers actually go about their work, how they plan their quota in the first place, how they plan each day, where they look for their various quotas and so on. To do this at all properly would have meant watching investigators at work or at least talking to and questioning a large number of them. This was not feasible. It has been possible, however, to talk to the field supervisors and to form a general picture of field practice.

The chief impression is of how much freedom for individual judgment and variation there remains for the interviewer, after allowing for the various controls and instructions which have been discussed above. By and large, each interviewer can choose whether to cover a small or a large area; whether they interview in the street, in factories or on the doorstep; in the morning, afternoon or evening. The quota cells are generally fairly wide, so that interviewers experience little difficulty early on, although the cases at the end may be quite hard to find.

Here we meet two different approaches to the task. Some interviewers like to spend the first day or two of their assignment looking for the types of persons whom they know to be difficult to find, and hope to spend the rest of their time filling in the easier cells in a more leisurely way. The other and, it would seem, much more common approach is to try to get well ahead of schedule in the first days by starting on the easy quota cells, and then to turn to the difficult part of the assignment with plenty of time to spare. On this approach, investigators tend to start with some street interviewing, turning to the factories and the homes later for their special classes. During the early, easy stage the investigator is, of course, also on the look-out for persons to put

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into the difficult cells. It has not been easy to find out which the generally difficult cells are, and no figures are available to show how long it takes investigators to complete various parts of an assignment.

Towards the end of an assignment, whether the scheme consists of interrelated or independently set controls, the interviewer may experience considerable difficulty. One wonders how much dishonesty there is at this stage. It must be very tempting for an interviewer, needing a Female, Class A, aged 65, to "consciously misjudge" a respondent's class to be A, when it is obviously B or C. No findings on this kind of cheating are available, but the danger is widely recognized. One organization instructs its investigators not to spend a long time looking for the "last person", but to try to get as near to the requirement as possible and then to record the characteristics *as found*, and on no account to force the person into the wrong quota cell. This is a realistic recognition of the problem.

It may be noted that classification questions are generally asked at the end of the interview. This is quite safe early in the assignment, when cases are required for all the cells. Towards the end, however, it would lead to the wastage of a number of interviews. One organization allows the classification data to be asked at the beginning if only a small and difficult part of the quota remains. Another always has the classificatory questions asked at the beginning, recognizing that this may affect the quality of the interview but wishing to avoid wasting any interviews.

PART III.—*The Problems for Research*

On the basis of this survey of current practice, we must now attempt to decide which are the critical aspects of quota sampling on which our research should be focused. We shall not discuss the methods or forms of the experiments, but will merely list the problems requiring attention. The danger of any research is that too much will be attempted in one experiment. This particular project will certainly need several lines of attack, and a series of experiments, rather than a single one. We shall try to distinguish as far as possible between the major problems, around which the research should be planned, and the subsidiary ones, which should be included if and when the design of the experiment permits.

One factor increases the difficulty of this research enormously, namely, the absence of data against which the *validity* of quota samples can be checked. The most easily available data—such as age and sex—are, by definition, correct on quota samples. On other data there are few reliable checks. The results of the 1951 Census will substantially alter this situation, but they will not be ready for some time. The results of random samples—although these may themselves not be properly representative—constitute the best standard available, and will have to be used in judging the accuracy of quote samples.

The Major Questions

1. *Representativeness within Quotas*

Three main groups of possible bias in quota sampling can be distinguished: that due to the basis or definition of the controls; that due to unrepresentativeness within the quota cells; and that due to the peculiarity of the interview situation. Without doubt, it is the second of these which constitutes the main danger of bias and which is the top research priority.

(*a*) Are certain types of person systematically under- or over-represented in quota samples? The collection of detailed classification data on quota samples would show whether an adequate spread is secured within quota cells. If there is any bias here, what are its origins and causes? If this detailed classificatory data were obtained by a large number of interviewers, one would find out the degree of variability with respect to the various factors. This could be compared with similar random material.

(*b*) Related to the above point is the question whether certain types of areas are systematically under- or over-represented in quota samples. Furthermore, is the possibly inadequate spread obtained by street and home interviews corrected by factory and office interviews?

These questions of geographical spread are now, in fact, being investigated. The addresses of respondents interviewed in one town have been taken from the samples of the four organizations, and are being plotted for comparison with random samples for the same area, and with a population density map.

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(*c*) To what extent can any tendency of quota samples to be unrepresentative—with regard to people or areas—be corrected by stricter instructions to interviewers, more extensive training or, most important of all, by the use of further controls? Supplementary to this, what are the effects on interview quality of further restricting the interviewer's freedom and what is the effect on costs?

2. *Checks*

Can currently used checks be improved and others developed so that there is a far stricter control over interviewer honesty and accuracy? Good checks are especially vital on two questions: whether the interview actually took place, and whether any distortion of classification data takes place in order to fill the quotas. Checks on the quality of the interview are, of course, needed in all types of sampling, and are not a special concern of this research.

3. *Training and Experience*

It would be useful to evaluate the importance of training and of experience of interviewers as regards the speed and accuracy of quota completion and the representativeness of the final sample.

4. *Social Status*

What is the extent of disagreement and reliability in placing respondents in social class groups? Is there a biasing tendency in the grading? (This is a problem in which sociologists would probably have considerable interest.) Can anything be done to make this sort of control more reliable and less vague?

5. *Refusals*

An effort must certainly be made to gain some knowledge of the unsuccessful interviews. How many people refuse, what sort of people are they, and what are their reasons for refusing?

The Subsidiary Questions

6. *The Quota Scheme*

Is bias introduced by the setting of independent rather than inter-related controls due to the possible "pairing" effect? How does interviewer efficiency differ on the two methods?

7. *Cost*

What are the costs of the various components of random and quota sampling respectively? Data on this can be obtained quite easily as a by-product of the experiments.

8. *Classification Data*

Is it better to ask the classification data at the end of the interview, thus risking interview wastage, or to ask them at the beginning, with the risk that the quality of the interview may be affected?

9. *Location of Interviews*

To what extent is the quality of the interview affected by its location, i.e., whether it takes place in the street, in an office or factory, or on the doorstep?

Two problems of major importance, but of a long-term nature, remain:

10. Can quota sampling be organized in such a way that, while retaining its practical advantages, it also becomes more satisfactory from a theoretical viewpoint? If the interviewer's movements were sufficiently controlled, if it were possible to sample interviewers at random, could quota sampling satisfy the basic conditions of randomness, so that standard errors could legitimately be attached to the results? This point is related to 1 (*c*) above and is of critical importance.

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11. If certain biases are found to be inherent in quota sampling, when do they matter? This is not a question that can be answered by an experiment, but only by the accumulation of survey data over a long period. The question really is, to what extent are various data of environment, behaviour and opinions—all the subjects which surveys set out to study—correlated with the variables which are controlled in quota sampling and, more important, with those which are not?

The Stages of the Research.

We are proceeding in two stages:

(*a*) We are comparing the *results* of quota and random sampling. These comparisons are being made on the basis of data collected by the professional organizations in the ordinary course of their work, not by an *ad hoc* inquiry. The comparisons cover data of a classificatory nature, as well as ordinary survey questions.

(*b*) The major stage will consist of special experiments, designed to throw light on the problems listed above.

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The Sources and Nature of Statistical Information in Special Fields of Statistics

Clothing Statistics

By J. R. Weatherburn

The cost of clothing is the largest single item of consumer expenditure apart from food, and much interest in clothing statistics arises primarily in relation to consumer need or consumer demand. There are many stages in the manufacturing and distributive chain between the raw materials and the final purchase of the finished garment. The manifold alternative uses of the raw materials and the "semi-manufactured" goods make it expedient to consider first the available consumer statistics on clothing expenditure, and then to proceed backwards to the raw material sources. The export of clothing is of relatively minor importance, but will be covered with the manufacturing data. War-time rationing of clothing led to the collection of a wide range of statistics for various administrative purposes. These are mentioned in all cases where they have been published, even if the data refer only to a limited period.

Consumer's Expenditure

In 1937–38 the Ministry of Labour conducted an inquiry into working-class expenditure (4). Figures were supplied for a full year by 2,225 households and it was found that their average expenditure on clothing was 5*s*. 10*d*. per head per week, or 6·7 per cent. of their total expenditure. This inquiry was followed in 1938–39 by an investigation into the expenditure of middle-class households undertaken by the Civil Service Statistical and Research Bureau (3). In this case clothing expenditure was given for 706 households and amounted to 12*s*. 6*d*. per head per week, or 7·2 per cent. of total expenditure.

In addition, data were collected from a panel of consumers by the Board of Trade between 1941 and 1944 in connection with clothes rationing. This was concerned with two aspects of the clothing situation, firstly the money and clothing coupons spent on each garment, and secondly the state of each person's wardrobe. The expenditure information was collected continuously, and four separate inquiries were made in 1942, 1944 and 1945 to determine the quantity and types of garments which consumers had "in stock". Much of this information has been incorporated in a paper on "The Statistical Background of Clothes Rationing" by Miss P. Ady (1).

In 1950 consumers' expenditure on clothing was estimated at £831 million which was 9·2 per cent. of total personal spending, the cost of clothing constituting the largest single item apart from food. This figure of total purchases is the most complete statistic available for clothing at any stage. It has been estimated for each year from 1938 onwards, and is published in the White Papers which deal with the National Income and Expenditure of the United Kingdom. In Table 1 are shown clothing purchases for the years 1938 and 1946 to 1950 at current prices, and also for the post-war years revalued at 1948 prices.

The effect of rationing in reducing the proportion of money spent on clothing is illustrated by the series of figures.

Prices

Price changes are very important in the apparel field over the war and post-war years for two reasons. The changes in clothing prices have been substantial and different from those for other consumer goods, and this may well have led to a tendency for change to occur in the proportion of money spent on clothing. Further, there is a certain section of demand which arises from necessity and the maintenance of minimum standards of dress, and it is a demand which is largely related to volume of purchases in terms of quantity of garments apart from quality changes. It is therefore well to consider after the information on consumers' expenditure what data are available on prices. One estimate of price change is that inherent in the revaluation of consumers'

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TABLE 1

Personal Expenditure on Consumer Goods and Services

£ *million*

	1938	1946	1947	1948	1949	1950
At current market prices :						
Total . . .	4,335	6,886	7,622	8,204	8,567	9,041
Clothing—						
(*a*) Value . . .	373	503	572	685	782	831
(*b*) % of total . .	8·6	7·3	7·5	8·3	9·1	9·2
At 1948 *prices :*						
Total . . .		7,946	8,187	8,204	8,360	8,610
Clothing—						
(*a*) Value . . .		568	630	685	734	766
(*b*) % of total . .		7·1	7·7	8·3	8·8	8·9

expenditure at fixed prices which is given above in Table 1. A price series is published in the White Papers alongside the revalued figures, and was 112 for men's and boys' wear and 107 for women's, girls' and infants' wear in 1950, with 1948 taken as 100 in each case. For earlier years a price index was given based on 1938 as 100. This price index takes into account so far as is possible the pattern of expenditure in the year in question and price changes for all types of goods.

Further price data on clothing are provided by the Ministry of Labour Interim Index of Retail Prices, which measures changes in the retail selling price of clothing of types commonly sold to working class households. A figure is published each month, based on June, 1947 = 100, showing movements in the price of clothing and footwear (no details are given for clothing separately). Since this series covers types of goods normally sold to working-class households, the price changes must relate very largely to utility goods and throw little light on the non-utility sector, which is also important.

The new Board of Trade Index of Wholesale Prices for clothing (excluding footwear) is more broadly based than the Retail Prices Index, but the problems of adequate representation of the non-utility field, in which the fashion element is much in evidence, have not yet been fully solved. The greater breakdown of the information, even though at this stage, makes it more useful in some contexts than the retail series.

Other but less usable data are contained in the various orders issued by the Board of Trade, which list manufacturers', wholesalers' and retailers' maximum prices for the different utility garments.

Retail Statistics

Reverting to output and consumption statistics, the next point at which information is collected is retail sale. Such data on sales and stocks are published in the *Board of Trade Journal* each month, and are derived from panels of various types of shops. These fall into two distinct groups from which information is obtained in slightly different ways, though in both cases from a sample of shops.

For the larger units comprising department stores, multiple chains and co-operative societies, the sample of contributing firms is a voluntary one and not specifically randomly distributed. This is, however, not such a serious defect as it might appear at first sight, since the field from which the firms are drawn is a limited one in which the units are very individual, and the collaborating trade associations have made efforts to recruit a group of firms which are representative both geographically and by type and class of trade. Statistics covering these firms were prepared by the Bank of England from 1930 to 1947, but are now collected by the Board of Trade. The firms provide considerable detail about the value of their turnover, and much information can be extracted from the published articles. Table 2 shows the movements in annual value of sales

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by each group of contributors for the two main categories of women's, girls' and infants' wear and men's and boys' wear. Some sub-series of index numbers for women's outerwear, women's underwear, girls' and infants' wear and dress materials are published for the groups of firms as a whole; these are based on returns from a smaller group of shops, since some firms are unable to sub-divide their takings according to the kind of goods sold. For other categories, such as women's stockings, the information is not good enough to permit the calculation of index numbers and is expressed as the percentage change in the value of sales compared with a corresponding period a year earlier. The changes in trade in various areas of the country, which are peculiar to this set of statistics, are also recorded, and there is a series of area index numbers for apparel, which includes footwear as well as clothing. The final piece of interesting information provided by the large firms is the estimated value (at cost) of their stocks each month. For men's and women's wear index numbers of the value of stocks are prepared, but figures are not provided by all firms in the sample, and the data are therefore much less reliable than the sales figures. Nevertheless these limited figures are the only available evidence on the change in retail stocks.

The large section of retail trade in the hands of the smaller independent shops can be followed by means of the separate statistics prepared for this field by the Board of Trade. These are derived from a number of panels of independent shops which contribute on a voluntary basis; they were, however, first selected on a scientific principle to give an adequate cross-section of the trade. The majority of smaller firms are not able to give any analysis of their sales, so shops were only eligible for these panels if their trade was primarily in one type of goods, that is, men's wear or women's and children's wear, in the case of clothing. This qualification has been used throughout the construction of the samples, so that firms need only be asked to give their total sales figures. It should be borne in mind that this dependence on specialists may possibly cause a bias in the figures, so that they may not be completely representative of general clothing sales.

TABLE 2

Index Numbers of the Value of Sales: Annual Average

(1947 = 100)

	1946	1947	1948	1949	1950
Women's, Girls' and Infants' Wear:					
Department stores	89*	100	111	125	124
Multiple chains	88*	100	133	173	218
Co-operative societies	88*	100	118	136	148
Drapers	89*	100	117	130	129
Men's and Boys' Wear:					
Department stores	78*	100	117	132	137
Multiple chains	99*	100	149	202	257
Co-operative societies	87*	100	123	145	161
Men's outfitters (inc. bespoke tailors)	86	100	119	130	135

* Approximate.

In September, 1947, shortly after these statistics were first started, there were 365 drapers and 228 men's outfitters and tailors contributing. These numbers have recently been much increased, particularly in the case of drapers. The contributors have been recruited to replace firms which have fallen out and to increase the panels beyond their original strength. A series showing the trend in sales by smaller retailers has been incorporated in Table 2 with the figures for the larger units. There is no information available to indicate the possible errors of these figures.

Seasonal patterns of sales and trends can be found from the Board of Trade figures. The seasonality of consumer demand is an important factor in the clothing industry, and although

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it was largely eliminated during the period of rationing, it has emerged again since the beginning of 1949.

For many purposes a weighted mean of all the series in Table 2 is needed to show movements in retail trade as a whole. This is now important in view of the diverging movements of the sales by the different types of shops. It is hoped that the Census of Distribution will eventually provide the necessary weights. Some information on this problem relating to pre-war is given by Mr. J. B. Jeffreys in his book on the Distribution of Consumer Goods (2). The Census will also provide figures for the number of retail clothing shops in the country. The only previous data on this subject were published in an article in the *Board of Trade Journal* of June 3rd, 1944. This gave an analysis of the numbers of shops opening coupon banking accounts in 1942 in connection with the beginning of clothes rationing. At that time there were 86,150 shops selling clothing or footwear, of which 61,550 were selling women's, girls' and infants' clothing and 48,000 were selling men's and boys' clothing. In addition there would be a number of shops selling small quantities of clothing which did not need to open coupon accounts.

Wholesale Distribution

Moving one step back in the distributive chain brings us to the wholesalers, who have considerable importance in the clothing field. Not all types of clothing pass through the hands of wholesalers to the same extent, and it is generally known for example that some types of men's outerwear go mainly direct from manufacturers to retailers. The only data at present available which throw light on the channels of clothing distribution were collected from clothing makers-up by the Board of Trade during the war and published in the *Board of Trade Journal* of September 29th, 1945. These figures did not cover hosiery, and may not apply since the end of rationing, but they do represent a picture of the distributive pattern at one point of time.

Data on sales and stocks of a large and representative group of the major wholesale textile houses have been prepared for a number of years by the Bank of England in collaboration with the Wholesale Textiles Association. The firms deal primarily in clothing and piece-goods, but they also handle some household goods and small quantities of footwear, sports goods, etc. In 1947, 158 firms were contributing to the statistics, and 50 per cent. of their turnover consisted of women's wear, with 18 per cent. men's wear and a further 7½ per cent. piece-goods. The returns, like those from the larger retailers, are made in value terms and for a range of types of goods separately. For the main groups of women's wear, men's wear and piece-goods, index numbers are prepared for both sales and stocks, and year-to-year changes in the level of sales of sub-groups such as women's outerwear are also given. These figures are published every month in the *Board of Trade Journal*.

During the war clothes rationing led to a need for a more detailed knowledge of what was happening to wholesalers' sales and stocks in terms of quantities. Returns were collected monthly by the Board of Trade from many clothing wholesalers and used to compile indexes of sales and stocks of a very wide range of individual garments, based in each case on the number of garments. These series were first published in the *Board of Trade Journal* of April 5th, 1947, and kept up to date thereafter until 1949, when, with the improvement in clothing supplies, it was no longer necessary to collect the returns. Owing to the fact that this information was collected for the years from 1943 onwards when trading conditions were abnormal, it has little value in terms of current or future assessment of the clothing situation. It is, however, of interest historically, and demonstrates that it is possible to collect such data.

Manufacturing Stages

The short-period statistical information available is less satisfactory on manufacturing output than at the distributive stages. A single figure for the monthly output of clothing is published as a constituent of the Interim Index of Production in the *Monthly Digest* and the *Board of Trade Journal*, but this figure embraces the activity of the various sections of the making-up industry together with footwear, and does not include the hosiery and knitted goods trades.

The main data on production are provided by the various Censuses of Production, which from 1948 onwards are being taken annually. The amount of information varies from year to year, but considerable detail was collected for 1948 and also in the made-up clothing industries for

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1946. The latest pre-war statistics are given by the 1935 Census of Production and the 1937 Import Duties Act Inquiry; preliminary reports on the latter were published in the *Board of Trade Journal* between June and August, 1939. The Census of Production normally covers in full only those firms with, on average, 10 or more employees during the year, but for made-up clothing the output of the small firms forms a relatively important part of total production. The 1948 Census of Production required some details of output also from the small making-up firms with less than 10 workers, and for the first time since 1924 data will be available for this sector of the trade.

During the war a special survey of the made-up clothing industry was carried out. This has already been mentioned in connection with the distribution of clothing, but the main information covers employment in June, 1942, production in January–June, 1942, the methods of production then in use and the numbers of sewing machines owned by the industry. The results of the inquiry are to be found in the *Board of Trade Journal* for September 29th, 1945.

At this stage it is convenient to mention the import and export statistics for clothing. Export trade is not very important for apparel, and is normally carried on by either manufacturers or wholesalers. A considerable amount of information is published monthly in the Accounts relating to the Trade and Navigation of the United Kingdom. A number of different classes of garments are separately distinguished with, in some cases, quantities as well as values, and knitted goods are in all cases shown separately from those of woven cloth. For some groups of goods the value of exports to individual countries are shown, and this detail is given for the total value of all apparel exports. Similar information, but in less detail, is given for imports. Detailed figures are given once a year in the annual volumes. During 1948–50 the total value of external trade in apparel was given as follows:

	£ *million*		
	1948	1949	1950
Exports of United Kingdom Production .	31·4	29·5	35·6
Imports into the United Kingdom . .	3·1	4·4	8·6

On a short-period basis there is no information published on the output of the made-up clothing industries, but a series of employment figures appear in the *Monthly Digest* which may give some indication of the state of the trade. Separate figures are given for tailoring, dress-making, and the making of overalls, shirts, underwear, etc. A similar series of figures appears for the hosiery and knitted goods trade, but in this case there is a number of production data which are generally more useful. Quantity output data is collected, with great detail in the utility field, also yarn usage statistics, the value of production and export sales. Some of these figures have been published regularly in the *Monthly Digest of Statistics*. The series of figures begins in 1945, and although the periods covered by each set of figures have varied, the current data are the quarterly output of the following types of garments:

Men's and youths' pullovers and cardigans, vests, pants and trunks.
Women's and maids' jumpers and cardigans, vests, knickers and pantees.
Children's and infants' outerwear, underwear.
Men's socks and stockings.
Women's stockings.
Children's stockings.
Women's and children's socks.

Similar information taking into account exports and imports and thus showing quantities available for the home market has been published in the *Board of Trade Journal* in a series of articles on Supplies of Consumer Goods to the Home Market. The data, rather more detailed than that in the *Monthly Digest*, covered the period January, 1945, to October, 1949, when the series was discontinued. The same series also contains data on the home market supplies of some other small sections of clothing, namely gloves, corsetry, handkerchiefs and nursery squares.

The final set of strictly relevant statistics is that supplied by the merchant converters, giving details of their deliveries of finished non-wool cloth for clothing. These deliveries are classified according to the end use of the materials into shirtings, nightwear and underwear cloths, dress

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and blouse cloths, overall cloths, raincoatings, linings and interlinings and a residual category. In addition to this breakdown, the total figures are subdivided between utility and non-utility cloths. These statistics have a direct but unfortunately not precisely defined relationship with the quantities of garments made from woven cotton or rayon cloth which will be available to the consumer at some later date. A summary of the annual figures since 1945 is given below; the details can be found in the articles on Supplies of Consumer Goods for the Home Market in the *Board of Trade Journal*. A corresponding series for wool cloth for clothing was available for the period 1945–49 and the figures have been appended to Table 3. From November, 1949, onwards figures in respect of utility wool cloth only have been collected by the Wool Industry Bureau of Statistics on behalf of the Board of Trade.

TABLE 3

Deliveries of Woven Cloth for Clothing
(*monthly rate : M.sq.yds.*)

	1945	1946	1947	1948	1949	1950
Cotton and linen—						
Utility	17·8	14·9	26·7	21·4	20·4	24·1
Total	21·5	30·2	33·3	29·8	33·0	43·8
Rayon and nylon—						
Utility	9·4	12·0	11·3	12·5	12·2	15·7
Total	12·1	15·7	15·7	17·5	19·3	25·1
Total non-wool . .	33·6	45·6	49·0	47·3	52·3	68·9
Wool—						
Utility	11·1	15·5	14·9	13·5	15·5*	N.A.
Total	13·8	18·5	19·1	18·6	20·6*	N.A.

* Monthly rate based on January–October.

For both wool and non-wool woven cloth, series showing total production are published in the *Board of Trade Journal*. These total output figures necessarily include cloth for export and for many industrial uses beside the making of clothing, but even so they are of some interest in relation to clothing. Yarn output figures are also given in the same series of articles (in considerable detail by counts in the case of cotton), but this is a stage even further away from the made-up garment. Hosiery output is more directly affected by yarn supplies, and a series of articles in the *Board of Trade Journal* on rayon output and deliveries shows the weights of rayon yarns delivered to the hosiery industry in each quarter since the beginning of 1947.

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Wholesale Prices in 1951

By the Editor of "The Statist"

Method of Construction of the Index Numbers

The following table illustrates the method of construction of the index numbers. The index numbers here given are based on the average prices for the eleven years 1867–1877. Take, for instance, the *Gazette* price of English wheat:

		s.	d.				
Average, 1867–77		54	6,	average point.			
„ 1914		35	0,	64 or 36 per cent.	*below*	the average point.	
„ 1930		80	7,	148 „ 48 „	*above*	„	„
„ 1936		53	3,	98 „ 2 „	*below*	„	„

The individual index numbers, therefore, represent simple percentages of the average point. The 45 articles are grouped in six categories. They are shown in detail in Table 5.

The general average is drawn from all 45 descriptions which are treated as of equal value, and is the simple arithmetic mean.

Table 1

Construction of Index Number for 1951

1867–77 = 100

	Number of Commodities in Index	*Total Numbers*		*Index for* 1951
		1867–77	1951	
General average	45	4,500	18,081	402
Food	19	1,900	5,026	265
Vegetable food	8	800	2,440	305
Animal food	7	700	1,591	227
Sugar, coffee and tea	4	400	995	249
Materials	26	2,600	13,055	502
Minerals	7	700	3,610	516
Textiles	8	800	5,110	639
Sundry materials	11	1,100	4,335	394

Table 2

Annual and Monthly Index Numbers

1867–77 = 100

	Year	*Jan.*	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
1902–1911	74	73·9	74·0	74·2	74·5	74·9	74·5	74·5	74·3	74·3	74·5	74·4	74·8
1912–1921	148	145·2	146·3	146·9	147·7	147·9	147·2	147·9	149·2	149·0	149·3	149·1	149·2
1922–1931	120	122·7	123·0	122·5	122·0	121·0	119·3	119·0	118·0	118·0	118·6	119·2	118·5
1932–1941	97	96·0	96·5	96·5	96·8	97·3	96·9	97·5	97·8	98·7	98·8	99·4	101·4
1942–1951	231	221·4	224·1	224·6	227·3	228·0	227·1	226·7	227·3	231·2	235·3	238·5	241·2
1942	151	148·6	153·4	153·5	154·5	156·6	154·4	150·0	149·4	149·7	150·4	151·3	152·2
1943	155	153·3	153·2	154·0	154·9	155·6	155·4	156·0	154·4	154·6	153·7	153·9	153·9
1944	160	154·9	155·1	155·7	157·9	159·5	160·0	161·9	161·5	160·1	159·6	160·3	160·7
1945	164	161·4	161·5	162·1	162·4	164·0	166·7	165·2	163·2	162·7	162·7	162·7	163·2
1946	186	165·6	166·2	166·6	168·4	169·3	169·7	174·4	175·7	180·5	196·2	198·1	200·5
1947	230	206·7	209·6	212·1	215·9	216·5	218·1	223·4	225·9	228·9	236·0	240·8	246·5
1948	260	250·5	253·4	256·0	256·4	260·0	263·9	260·4	260·1	258·1	261·5	263·8	266·0
1949	274	267·6	266·8	265·4	272·0	269·2	267·2	263·3	262·5	285·7	291·5	293·7	297·4
1950	324	300·2	301·0	301·7	305·2	308·3	310·3	317·7	332·1	335·7	349·2	363·1	372·3
1951	402	404·8	420·5	419·3	425·7	420·6	405·2	394·5	387·9	395·9	392·0	396·9	399·7

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TABLE 3

Annual and Quarterly Index Numbers for Groups

1867–1877 = 100

	All Groups	Food				Materials			
		Total	Vegetable Food	Animal Food	Sugar, Coffee and tea	Total	Minerals	Textiles	Sundry Materials
1902–1911	74	71	66	88	49	77	90	70	74
1912–1921	148	146	136	167	100	154	166	151	148
1922–1931	120	115	101	150	80	122	137	128	110
1932–1941	97	88	84	116	49	103	131	94	91
1942–1951									
1942	151	140	170	148	66	160	184	163	142
1943	155	138	156	156	72	167	187	166	156
1944	160	137	152	156	73	178	197	182	161
1945	164	139	155	156	78	182	209	189	159
1946	186	140	155	154	88	219	239	231	198
1947	230	156	191	149	100	284	304	295	263
1948	260	171	217	155	107	324	368	348	279
1949	274	201	240	185	151	328	382	356	273
1950	324	235	268	204	224	390	416	491	299
1951	402	265	305	227	249	502	516	639	394
1950 1st Quarter	300·6	224·3	253·1	197·4	213·9	356·9	378·7	429·8	290·2
2nd ,,	307·9	232·7	272·4	203·0	205·1	362·9	379·1	442·1	295·1
3rd ,,	328·5	237·9	267·5	205·8	235·1	394·7	419·0	508·1	296·4
4th ,,	361·5	247·6	287·7	209·4	234·2	444·9	482·5	590·3	315·2
1951 1st Quarter	414·9	252·9	295·0	210·1	243·9	533·2	527·5	749·8	379·2
2nd ,,	417·2	265·4	317·5	214·8	250·6	527·9	512·1	718·1	399·5
3rd ,,	392·8	276·6	314·9	245·1	251·9	475·9	507·5	565·3	390·9
4th ,,	396·2	280·8	321·4	263·3	250·9	480·8	521·7	562·3	395·6

TABLE 4

Monthly Index Numbers for Groups

1867–1877 = 100

	Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1950													
Food:													
Total	235	226·1	224·4	222·5	228·9	230·8	238·3	235·2	238·9	239·7	246·2	246·2	250·4
Vegetable food	268	253·1	252·8	253·4	266·9	269·7	280·5	267·9	266·2	268·3	283·7	286·9	292·5
Animal food	204	197·4	197·4	197·4	200·6	204·2	204·2	204·2	204·2	209·1	209·1	209·1	210·1
Sugar, tea and coffee	224	222·4	214·9	204·5	202·3	199·3	213·6	224·1	245·0	236·2	236·2	229·4	236·9
Materials:													
Total	390	354·3	357·0	359·5	361·0	364·9	362·8	377·9	400·4	405·8	424·6	448·6	461·4
Minerals	416	382·8	382·1	371·2	375·0	382·5	379·7	401·1	419·2	436·6	464·1	492·5	490·8
Textiles	491	425·5	426·1	437·3	437·8	433·5	445·0	470·3	528·9	527·3	554·6	595·5	620·8
Sundry	299	284·4	290·8	295·5	296·2	296·6	292·4	296·2	295·0	298·0	305·0	313·9	326·7
1951													
Food:													
Total	265	251·7	253·9	253·2	261·0	265·7	269·5	275·4	276·6	277·3	277·8	278·9	285·8
Vegetable food	305	292·5	295·0	297·4	315·5	314·0	323·0	313·3	315·5	316·0	317·1	321·8	325·2
Animal food	227	210·1	210·1	210·1	210·1	216·2	216·2	245·1	245·1	245·1	245·1	245·1	259·6
Sugar, tea and coffee	249	243·0	248·4	240·3	241·3	255·5	255·1	250·0	251·8	253·8	254·0	249·3	249·3
Materials:													
Total	502	516·7	542·2	540·6	546·1	533·8	503·7	479·6	467·4	480·8	473·8	484·3	484·3
Minerals	516	520·2	538·6	523·6	523·9	523·1	489·4	485·4	513·5	523·6	522·4	523·1	519·6
Textiles	639	730·3	769·3	750·0	771·3	721·8	661·2	599·8	536·4	559·7	553·8	563·9	569·1
Sundry	394	359·1	379·4	399·2	396·9	405·9	398·2	388·6	387·8	396·2	384·6	401·9	400·2

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TABLE 5

Average Prices of Each of the 45 Commodities

1947 to 1951

			Average Prices					*Index Numbers* (1866–77 = 100)				
			1947	1948	1949	1950	1951	1947	1948	1949	1950	1951
Vegetable Food												
1	Wheat, English Gazette	*s.* and *d.* per qr.	71 9	90 0	99 6	110 8	122 10	132	165	183	203	225
2	American	,, ,, ,,	68 10	73 4	88 3	107 9	106 0	123	131	158	192	189
3	Flour, G.R.	*s.* per sack (280 lb.)	40	40	43½	52	56⅜	87	87	95	113	123
4	Barley, English Gazette	*s.* and *d.* per qr.	88 7	95 8	92 4	99 8	124 6	227	245	237	255	319
5	Oats, ,, ,,	,, ,, ,,	50 9	58 0	58 6	60 2	72 11	195	223	225	231	280
6	Maize, American mixed (*a*)	*s.* per qr.	43	43	72½	105½	127⅛	132	132	223	325	391
7	Potatoes, good English	,, ton	162	207	222	225	261	138	177	190	192	223
8	Rice, Rangoon cargoes to arrive	*s.* and *d.* per cwt.	49 6	57 6	61 0	63 0	69 0	495	576	610	630	690
Animal Food												
9	Beef, prime	*d.* per 8 lb.	80	79	103¼	114	125½	135	134	175	193	213
10	,, middling	,, ,,	72	72	88⅝	96	107½	144	144	177	192	215
11	Mutton, prime	,, ,,	101	100	127¾	140	152½	160	159	203	222	242
12	,, middling	,, ,,	81	81	92 3/16	98	100	147	147	169	178	182
13	Pork, large and small, average	,, ,,	98	99	127⅜	140	152⅜	188	190	245	269	293
14	Bacon, Waterford	*s.* per cwt.	124¼	154¾	159½	175¾	194	168	209	216	238	262
15	Butter, Friesland, fine to finest	,, ,,	126	122¾	134⅛	168¼	230½	101	99	107	135	184
Sugar, Coffee and Tea												
17	Sugar, Java floating cargoes (*b*)	,, ,,	27½	24⅛	26¼	40⅜	45⅜	96	85	92	142	159
18	Coffee, Ceylon plantation, low middling (*c*)	,, ,,	150	169	356	532	520½	172	194	409	611	598
	Rio, good	,, ,,	73⅜	79	145	297¼	395	115	123	227	464	617
19	Tea, average import price	*d.* per lb.	27·65	32·21	33·72	37·37	39·42	160	187	195	217	228
Minerals												
20	Iron, Scottish pig	*s.* and *d.* per ton	176 9	194 5	228 11	239 6	252·1	} 273	300	336	348	367
	Cleveland (Middlesborough) pig	,, ,, ,,	175 4	193 5	204 7	209 1	221·10					
21	bars, common	£ per ton	20 1/16	21¼	20	20	21⅞	248	258	244	244	263
22	Copper, Standard	,, ,,	130⅞	134	132¾	179	220⅝	175	179	177	239	294
23	Tin, Straits	,, ,,	426¾	547⅝	603½	744 1/32	1,073⅞	406	521	575	709	1,023
24	Lead, English pig	,, ,,	86⅞	97	104 1/16	111 5/16	163 9/16	424	473	508	543	798
25	Coal, Best Yorkshire House	*s.* per ton	48⅛	54¾	54¾	53	58½	219	249	249	241	266
26	average export price	,, ,,	47·61	74·07	72·97	73·65	74·88	381	594	584	589	599

TABLE 5—*cont.*

TABLE 5—*cont.*

			Average Prices					Index Numbers (1866–77 = 100)				
			1947	1948	1949	1950	1951	1947	1948	1949	1950	1951
Textiles												
27	Cotton, Middling American	*d.* per lb.	21·21	23·23	24·85	36·15	46·01	236	258	276	402	511
28	Fair Dhollerah	,, ,,	16·28	17·80	20·52	32·96	42·04	241	264	304	488	623
29	Flax, Medium grade continental retted	£ per ton	262	274	283¾	351	486	543	598	562	689	968
	Belgian import price	,, ,,	248	281·3	244·3	296·7	424·3					
30	Hemp, Manila for roping	,, ,,	92⅓	88⅓	105¾	144	183 7/12	385	396	363	435	547
	Italian S.B.	,, ,,	208/6	220	117⅞	195 7/12	243½					
31	Jute, Daisee ⅔	,, ,,	80	96 9/10	101½	112 7/16	168⅜	421	510	534	593	886
32	Wool, Merino, Port Philip, average fleece	*d.* per lb.	58·2	92⅛	92⅜	157 7/16	177¼	283	492	506	821	912
	Merino, Adelaide, average greasy	,, ,,	30	61⅛	65	98⅛	106½					
33	English Lincoln half hogs	,, ,,	22·7	33	38⅜	65¾	99	114	167	194	333	501
34	Silk, Japanese	*s.* per lb.	31⅜	23 9/16	25¼	38 5/16	37⅛	136	102	110	166	162
Sundry Materials												
35	Hides, River Plate, dry	*d.* per lb.	22 7/32	20 3/32	21 5/16	28 9/16	42¼	277	271	279	360	558
	River Plate, salted	,, ,,	19 7/32	20 5/16	20 7/16	26 13/16	38 1/16					
	average import price	,, ,,	21·71	20·72	21·43	27·08	47·27					
36	Leather, dressing hides	,, ,,	40	43⅜	45	58	80¾	284	311	328	373	516
	average import price	,, ,,	58⅝	64⅝	69 1/16	71 11/16	98 3/32					
	Tallow, Town	*s.* per cwt.	57⅞	60	60	80⅛	109 5/16	129	133	133	178	243
	Oil, palm	£ per ton	89⅝	99¼	99¼	100 3/16	108⅝	230	254	254	257	278
	olive	,, ,,	330	329	320	322	387	660	658	640	644	774
	linseed	,, ,,	193¾	193 15/16	149⅝	132 7/16	169	450	456	385	417	522
	Seeds, linseed	*s.* per qr.	211¾	216¾	197	243¼	301⅛					
41	Petroleum, motor spirit (c.i.f.)	*d.* per imp. gall.	7·69	9·38	9·61	11·67	12·66	48	59	60	73	80
	Kerosene (burning oil) c.i.f.	,, ,, ,,	6·83	8·74	8·51	10·55	11·41	108	138	135	167	181
	gas oil, c.i.f.	,, ,, ,,	6·52	8·69	7·78	9·84	11·19	164	218	195	247	281
42	Soda, crystals	*s.* per ton	107½	107½	107½	107½	125	117	117	117	117	136
43	Sodium nitrate	*s.* per cwt.	17⅞	19¾	20½	21¼	27⅜	128	141	146	155	195
44	Indigo, Bengal, good consuming	*s.* per lb.	7	7	7	7	9⅛	97	97	97	97	126
45	Timber, hewn, average import price	*s.* per load	187·43	215·02	207·09	228·33	367·83	418	498	493	534	806
	sawn, or split, average import price	,, ,,	289·20	352·82	354·37	380·46	550·31					

(*a*) Argentine maize (Feeding Stuffs) from 1941. (*b*) Raw centrifugals. 96 per cent. Pol,. from 1924. (*c*) East India, good middling from 1908–1947; Kenya from 1948.

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TABLE 6

Index of Silver Prices

The base of the Index Numbers given below is 60·84*d.* per standard ounce = 100, this being a partiy of 1 fine oz. of gold to 15½ standard ozs. of silver.

	Index Number		*Price per oz. Standard* (d.)	
	Average for period	*At end of December*	*Average for period*	*At end of December*
1942 . . .	23½	23½	18·1	18·1
1943 . . .	23½	23½	18·1	18·1
1944 . . .	23½	23½	18·1	18·1
1945 . . .	30½	44	23·1	31·1
1946 . . .	48⅝	55½	36·7	41·6
1947 . . .	44 7/16	45	33·3	33·8
1948 . . .	45	42½	34·1	31·9
1949 . . .	49⅕	64	32·8	33·3
1950 . . .	64⅕	70	33·7	36·4
1951 . . .	77 7/32	77	40·5	40·1

TABLE 7

Gold and Silver: Production

	Gold Value of output* (£ *thousand*)	*Silver* (*million ounces*)					
		Total	*United States*	*Mexico*	*Canada*	*Australia*	*Other Countries*
1902–1911 . . .	818,170	1,879·3	561·2	670·6	153·5	152·0	341·9
1912–1921 . . .	850,973	1,862·4	657·1	542·0	230·1	73·3	359·9
1922–1931 . . .	823,978	2,414·7	585·6	967·5	213·4	101·2	547·0
1932–1941 . . .	1,408,500	2,334·2	524·6	766·9	204·2	838·5	
1942–1951 . . .	1,096,400	—	376·2	563·0	176·4	—	
1942	146,300	..	54·5	84·9	21·8	71·8‡	
1943	113,200	..	44·8	71·2	18·6	59·3	
1944	103,300	..	37·4	63·0	14·8	57·7	
1945	98,400	..	29·3	61·1	14·0	46·4	
1946	99,900	..	21·4	48·3	13·6	47·1	
1947	101,400	..	36·1	49·2	13·5	44·6	
1948	103,100	..	36·1	45·8	17·0	46·0	
1949	109,400	..	34·6	49·5	17·6	44·3	
1950	112,200	..	42·0	49·0	22·5	44·2	
1951	109,200†	..	40·0	41·0	23·0	37·0	

* The value of gold is taken throughout at £4·25 per fine oz. † Provisional. ‡ Incomplete from 1942 onwards.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

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1.—*Logical Foundations of Probability*. By Rudolf Carnap. London: Routledge & Kegan Paul, Ltd., 1950. xvii + 607 pp. $9\frac{1}{4}''$. 42*s*.

The book under review is the first volume of a two-volume work on the problem of induction and probability. In this volume the emphasis is on the logical foundations; the second volume will be concerned with the more detailed development of the ideas put forward here, and comparison of the new method with other inductive procedures.

Chapter one, "On Explication", is devoted to certain methodological principles. Explication is "the transformation of an inexact, prescientific concept, the explicandum, into an exact concept, the explicatum". The argument in chapter two is that there are two fundamentally different concepts for which the term "probability" is used. Probability$_1$ is the degree of confirmation of a hypothesis h with respect to evidence e. Probability$_2$ is relative frequency (in the long run). The author contends that whilst probability$_2$ is factual, probability$_1$ is a semantical concept. "A sentence about this concept is based, not on observation of facts, but on logical analysis". Thus the present idea is different from Good's subjective notion of strengths of beliefs. It is not clear to the reviewer whether Jeffreys' idea of probability is subjective or not: the use of invariance criteria, for example, suggests that Jeffreys' arguments are more similar to Carnap's than to Good's. The primary purpose of the two-volume work is to construct an inductive logic, parallel to deductive logic, to act as an explicatum for the explicandum, probability$_1$. Probability$_2$ is only mentioned for comparison purposes, and is not discussed in detail.

Chapter three is concerned with some results in deductive logic that are needed in subsequent developments. Chapter four, the most interesting in the book, discusses the nature of inductive logic, before the exact development is begun in chapter five. The author argues in favour of a quantitative concept of confirmation (Keynes, for example, had only considered a qualitative concept), and introduces the necessary numbers through variations of the well-known comparisons with a fair bet and relative frequencies. Hence the calculus used is the usual one based on finite additive set-functions, though since the author considers only languages with a finite number of individual constants and slight generalizations therefrom, the calculus is particularly simple in operation. There is a discussion of how to choose an action and the rule, "Among the possible actions choose that one for which the estimate of the resulting utility is a maximum", is advocated.

In chapter five the development of the logic for the language systems already mentioned begins. He considers a class of c-functions, called regular, which measure the degree of confirmation $c(h, e)$ of a hypothesis h on evidence e. $c(h, e) = m(e.h)/m(e)$ where $m(e)$ is a measure function. Properties of this function are deduced and comparisons made with the systems of other authors. Chapter six contains a discussion of the notion of relevance of additional evidence, and chapter seven a discussion of a comparative (i.e., non-quantitative) system of inductive logic. In chapter eight the class of c-functions is reduced by considerations of symmetry, the individuals within the language being regarded as indistinguishable. Chapter nine is a long chapter on estimation which amounts to saying the estimate to use is the weighted arithmetic mean, the weights being the degrees of confirmation, and the variance should be used as a measure of precision. There is nothing like Gauss's theorem to justify this estimate. Indeed estimation is regarded as essentially

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solved once probability$_1$ has been explicated. This is, of course, the opposite procedure from that adopted by many statisticians who discuss the concepts of best estimate before or without the notion of probability$_1$. In the appendix a hint is given of the results of volume two where the c-functions are still further specialized to a unique function, denoted by c^*.

The book is excellently printed and the price is surprisingly moderate. Every chapter and section begins with a summary. This is very necessary in view of the author's diffuse style. He remarks: "I often wonder why many of the books I have read do not help me in the same way; could it be that the authors wish to compel me to read every word they have written?" There are some most helpful instructions in the preface as to which parts of the book readers with different experiences and interests should read first.

The author's main contribution is in the clarification of concepts. For example his first chapter on methodology and his later discussions on other axiom systems are most lucid and illuminating. On the other hand to the reviewer, a statistician, the construction of his system seems unnecessarily laboured. It would not be useful to criticize this system of inductive logic until the second volume containing the developments of the system based on c^* is available. There has already been some criticism by statisticians in the discussion on a very clear paper by G. Tintner (*J. Roy. Statist. Soc.*, A, **112** (1949), 251). The main point that it seems worth making at this stage is that the new method appears to have transferred the difficulties of inductive behaviour into difficulties of language. The language has to be so defined that all the individuals are treated on the same footing (the requirement of symmetry), and then all structures (that is, sets of situations which only differ in the individuals) are assigned equal measure (the c^*-function). The last requirement is severe, but even the first seems not to be universal. Suppose the evidence e consists of $2n$ individual $a_1, a_2 \ . \ . \ . \ a_{2n}$, the even numbered ones possessing the property P, the odd numbered ones possessing the property $\sim P$, and the two hypotheses considered are h, a_{2n+1} possesses P, and h', a_{2n+2} possesses P. The demand of symmetry requires that $c(h, e) = c(h', e)$, whereas the usual notion of confirmation, i.e., the explicandum, would suggest $c(h, e) < c(h' e)$ at any rate for large n. Any stochastic process will illustrate this difficulty. In general terms it seems that Professor Carnap has taken over the calculus of probability into his language system, but this language system must be such that probability obeys certain rules, such as that of symmetry. In the applications of the probability calculus the difficulty lies in deciding the numerical values; it is therefore factual. In the applications of Carnap's theory the difficulty lies in choosing the language. Perhaps volume two will tell us how this is to be done. For the moment we must wait and see how the method works, unless that is too pragmatic an approach for Professor Carnap, whose philosophy seems to be verging on idealism.

D. V. LINDLEY.

2.—*Probit Analysis.* By D. J. Finney. 2nd ed. Cambridge University Press, 1952. xiv + 318 pp. $8\frac{1}{2}''$. 35*s*.

Dr. Finney's admirable text-book has lost its youthful slimness and assumed something of a middle-age spread. This is due partly to the use of thicker paper in the new edition, and partly to an important new chapter on recent developments of the subject. The topics dealt with in the new chapter are: alternatives to maximum likelihood estimation (which Dr. Finney says in the preface he would have liked to discuss at even greater length, had he been completely re-writing the book); Wadley's problem, in which the number of subjects exposed at each dose is unknown, but assumed to follow a Poisson distribution; the use of probits in factorial and other designs; the recent work of Plackett and Hewlett on independent action of mixtures of poisons; the design of experiments for estimating percentage points other than the ED50; the method of "staircase estimation", proposed by Dixon and Mood, in which the subjects are treated individually, and the result of each test determines the dose to be applied at the next; and, finally, the interpretation of standard errors.

In addition to this completely new section, Dr. Finney has made some other alterations from the first edition. In particular he has suggested a slightly different method of solution of the maximum likelihood equations when natural mortality is taken into account, which enables the computations to follow the routine for multiple regression. Analogous changes have been made in the chapters on the Parker-Rhodes equation, and on quantitative responses. Appendix II, which outlines the mathematical theory of the probit method, has been re-written. There are some new tables and some extensions to the existing ones.

I have noticed two slight misprints in the material included for the first time in this edition: equation (9.14) on p. 180 should read $Y = a + b\lambda^i$; and on p. 182, line 7, the standard error of i should be 0·097, not 0·97.

There is still a good deal of room for research even in the simple quantal response situation, or very little is known about the small sample properties of the maximum likelihood solution or

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of its rivals. Another aspect of the problem to which more attention might be paid is the effect of rounding-off errors in the computation. For example, Dr. Finney usually takes the expected probits, at the beginning of each cycle, to one place of decimals. According to the theory of the maximum likelihood solution these expected probits should be linearly related to log-dose, a condition which will usually not be satisfied by the rounded-off values. It is conceivable that one cycle, starting from expected probits which are exactly linearly related to log-dose, will get nearer to the true solution than several cycles each starting from an imperfect straight line. Such rounding-off effects will usually be of no practical importance, but they may not be negligible compared with the effect of doing, say, three cycles instead of two, or with that of the corrections for grouping suggested by K. D. Tocher (which, curiously enough, Dr. Finney does not mention).

This book will continue to be the standard work of reference for all who are interested in the analysis of quantal response data. P. ARMITAGE.

3.—*Statistical Methods for Chemists.* By W. J. Youden. New York: Wiley, 1951 (London: Chapman & Hall). x + 126 pp. 9″. 24*s*.

Statistical methods are still unappreciated in many fields of science where they would be of great value. One reason for this is the shortage of adequate text-books; the same statistical techniques can be used in widely different contexts, but they can only be learnt by working examples, and a chemist or engineer finds some difficulty in applying to his own problems a technique described in terms of agriculture or biology. Dr. Youden's book is designed as an introduction to modern statistical methods for chemists and other laboratory workers. The title is in fact unduly restrictive, as the examples deal with both physics and engineering in addition to chemistry, the emphasis being on technology rather than research.

The book is unashamedly of the "cook-book" type, theory and proofs being completely omitted. Dr. Youden realizes the dangers of this approach, but balances them against the ease with which the non-mathematician can find his way about. One result is that the various methods are justified by examples of their use in a way which should convince the practical worker better than pages of mathematics. It is a pity, however, that there are very few references from which the worker with a liking for mathematics could trace out the theory underlying the methods.

A great deal of dead wood which encumbers the usual course of statistics has been cut out. After some introductory remarks, Chapter 2 deals with the assessment of precision, and the normal distribution, standard deviation, confidence limits and the variance-ratio test are all introduced. Chapter 3 deals with the comparison of averages by the *t*- and *F*-tests, and Chapter 4 with variance components and the design of simple sampling schemes. Chapter 5 on the straight line is somewhat inadequate, although the treatment of the straight line through the origin is fuller than usual; it would appear almost as if the author has had some difficulty in finding practical applications of linear regression.

The remaining chapters, about half the book, deal with various aspects of experimental design. There are discussions of interaction between factors and its use as an estimate of error, randomization and randomization tests of significance, randomized blocks and Latin squares. Incomplete blocks and Youden squares are illustrated by examples, and the final chapter deals briefly with confounding and fractional replication with factors at two levels. There are tables of *t*, 5 per cent. and 1 per cent. points of *F* and a table of squares.

The style of the writing is informal and several sections would make excellent lectures if read aloud. The discussion of basic principles is excellent, with a continual insistence on the link between the analysis and the method of collecting the data. There is perhaps rather too much emphasis on significance tests as against problems of estimation; the worked example of an experiment in randomized blocks gives an admirable explanation of the analysis of variance, but the treatment means are not worked out. This example also contains half a page on the expected variance in a sample from a Poisson distribution which will be gibberish to anyone with no previous statistical knowledge.

On the whole, Dr. Youden's book can be recommended to any laboratory worker who wants to know what statistics is for and how it can help him in his work, though he may not find it altogether convenient for day-to-day use. M. J. R. HEALY.

4.—*Elementary Principles of Statistics.* By A. C. Rosander. New York: Van Nostrand, 1951 (London, Macmillan). x + 693 pp. 9″. 45*s*.

This book is intended as an introduction to statistical methods. Most books of this kind have the needs of a particular user in mind. So far as can be ascertained, the author's speciality is sampling and certain of the industrial applications of statistics. An endeavour is made, however,

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to cover all the elementary groundwork. The result is a very long book which makes somewhat tiresome reading, although one must give credit to the author for his explanations of computational procedure and his lists of examples.

The four parts of the book are entitled "Basic Concepts", "The Distribution of Measurements", "The Distribution of Estimates" and "The Distribution of Test Statistics". Each has a number of chapters, but not everyone will agree with the author's classification of subject-matter under these four heads, nor with the inclusion of particular matter in individual chapters. An instance may, perhaps, be given. In the index, under "hypotheses, testing statistical correlation coefficients", we find the cases $\rho = 0$, $\rho = \rho_0$, discussed on pages 458, 459 and 476, in chapters headed "The Normal Probability Distribution" and "The t Distribution". On p. 458 ($\rho = 0$) we are first given an approximate standard deviation for r, without any qualifications; we are then told that if ρ is approximately zero a normal test can be used. Almost immediately afterwards we read that the appropriate test when ρ is zero is the t distribution (described on p. 476), and when ρ is large is Fisher's z transformation. What follows, under the heading "Testing the hypothesis that $\rho = \rho_0$", is a statement that a better method of testing, for $\rho = 0$ or $\rho = \rho_0$, is Fisher's z transformation. Incidentally, the "more precise" value of the mean of $z - Z$ "according to Kendall" is, of course, due to Fisher himself.

On the other hand, in the index, under "coefficient, correlation, tests of significance", we are only referred to pages 609–11 of a chapter headed "Analysis of Covariance and Correlation". We are first given, in a section entitled "Tests of Correlation Coefficients", an approximate formula for the variance of r which differs from the square of the corresponding expression on p. 458, and which incidentally has a misprint (ρ should read ρ^2). We are then given all over again the t and z transformations of r, previously dealt with on pages 476 and 458–9 respectively.

This example suggests that not sufficient care has been given to the compilation and indexing, and hardly inspires the reader with unqualified confidence in the book as a whole. Not everyone will agree with the author's selection of the "high points in the history of statistical theory and practice". As a matter of interest, the names of the two best-known American statisticians were looked up in the index. One is not there at all, while the other is only mentioned once in a footnote, as the chairman of a committee on election polls and forecasts. J. WISHART.

5.—*Statistics and their Application to Commerce*. By A. Lester Boddington. 10th ed., completely revised and rewritten by A. R. Ilersic. London: H.F.L. (Publishers), 1952. xiv + 451 pp. 8¼″. 25*s*.

This completely revised and rewritten edition bears evidence that Mr. Ilersic has taken considerable note of a review in this Journal of the ninth edition (*J. Roy. Statist. Soc.*, **112**, 484). This is all to the good since teachers, and others responsible for preparing reading lists, may now hope for a decent burial of the eight pre-war editions which so steadfastly clung to errors consistently pointed out in earlier reviews both in this and other statistical journals.

Mr. Ilersic has rewritten this book so as to make it an acceptable text primarily for students working for professional examinations. These are largely interested in the subject as a subsidiary paper in their examinations for which a great many prepare by correspondence courses. This book provides good material and encouragement to look beyond the examination room into the real world. Whether a great many of these students ever use their elementary statistical knowledge frequently depends upon the business manager, who still is frequently very sceptical. In this case, however, there is the real danger that, despite the warnings scattered throughout the book, the simplicity of the methods outlined will be so attractive as to result in the uncritical acceptance of an application of a method. A knowledge of the limitations upon the applicability of statistical techniques is as important as the power to diagnose that a problem is one requiring statistical treatment. From a purely practical point of view this book alone would set restrictive limits upon what the business statistician could do. To this end the suggestions for further reading given in Appendix B will be useful although rather restrictive. In this connection, too, the rather high proportion of footnote references to papers in this Journal may raise a problem since it will not be of easy access to most students following correspondence courses.

There are some points of detail which the reviewer would like to note:

p. 76. "cross-hatched" or "hachured" for "cross-hacheted".
p. 84. The footnote might have referred to the considerable notes on pages 276–278 and pages 357–361.
p. 92. If pages 335–341 were in Chapter V this would make the treatment of diagrams compact, and allow point No. 4 to cover the position where no zero-line can be shown.

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p. 114. Some further explanation of the new symbols in the footnote would help the student here.

p. 176. The description of the sampling distribution merits some slightly more extended treatment.

Ch. X. There is some confusion between estimation and tests of significance, and in general the treatment may raise more problems in the mind of the inquiring student than it solves. For example, it is not brought out clearly that one of life's practical difficulties is that generally one does not know the value of the population standard deviation and use of the sample estimate necessitates certain precautions.

p. 191. The range is stated on page 149 to be of little use, but in connection with control charts it is shown to be of considerable importance. Some helping hand is required here to prevent the elementary student losing his sense of security.

p. 268. The printing of subscripts in the formula at the foot of the page has got out of alignment.

p. 242. The warning about the myth of the Trade Cycle could have been reinforced by adopting the modern approach in dealing with "oscillations" rather than with "cycles and seasonals."

None of these points is fundamental, and it is very clear that a conscientious student coming to statistics for the first time would both enjoy reading and profit from Mr. Ilersic's book.

W. R. BUCKLAND.

6.—*Tables to Facilitate Sequential* t-*Tests.* National Bureau of Standards: Applied Mathematics Series, 7. Washington: Government Printing Office, 1951. xx + 82 pp. $10\frac{1}{4}''$. 45 cents.

The ordinary t-test is used to test whether the mean μ of a normal population is some value θ_0, the variance σ^2 being unknown. The significance level is the probability α of rejecting the null hypothesis, that $\mu = \theta_0$, when it is true. For any sample size n_0, one can work out the probability β of accepting the null hypothesis when in fact μ differs from θ_0 by $\delta\sigma$ (in either direction, if the t-test is two-sided). In certain applications, probably mostly industrial, it might be possible to sample sequentially, so that the sample size required varies from one sample to another. These important tables were constructed in 1945 for use in a sequential analogue of the two-sided t-test. In order to use them it is necessary to decide what properties one requires of the test: that is, one must choose α, β, θ_0 and δ. There will then be a fixed sample size t-test, of size n_0, say, with which the sequential test can be compared for economy in sampling.

A. Wald proposed a two-sided sequential t-test, as an example of sequential tests for composite hypotheses. This test has always seemed unsatisfactory, as the theory involves the use of a weight function for the unknown standard deviation, and Wald's choice seemed rather arbitrary. The probability ratio used in Wald's test can be expressed as a function of $z = \{\Sigma(x - \theta_0)\}^2/\Sigma(x - \theta_0)^2$, where x is an individual observation, and at each stage of the sampling the summation extends over all the observations so far made; z is closely related to Student's t.

K. J. Arnold and the late H. Goldberg observed that the problem could be reduced to a Wald probability ratio test for two simple hypotheses about the distribution of z. On the null hypothesis $\sqrt{z}$ is distributed (apart from a constant) as Student's t; on the alternative hypothesis the distribution is essentially that of non-central t (cf. the paper by Rushton, *Biometrika*, 37, 1950). The probability ratio, like that in Wald's original test, can be expressed in terms of the confluent hypergeometric function, the functions of z in the two tests being very similar. It is this second test for which the present tables are designed, although they can also be used for Wald's test.

The boundary values for z at each stage of the sampling have been obtained by inverse interpolation in tables of the confluent hypergeometric function. The tables show these boundary values in terms of the sample size, n, so far reached, the constant δ, and a constant L, which is put equal to $ln\{(1 - \beta)/\alpha\}$ or $ln\{\beta/(1 - \alpha)\}$, according as the upper or lower boundary for z is required. The ranges covered are $\pm L = 2$, ln 19, 3, 4, ln 99, 5, 6, 7; $\delta = 0{\cdot}1\ (\cdot 1)\ 1{\cdot}0\ (\cdot 2)\ 2$, $2{\cdot}5$, and those values of n most likely to be needed up to 200.

In an excellent Introduction K. J. Arnold describes the theory of the test, the use of the tables, and the method of their construction. If no decision has been made when the limits of tabulation of n are reached, the test can be curtailed by adopting some decision rule at this stage; the effect on the probabilities of incorrect decisions is probably negligible. Alternatively, for sample sizes above 200, a simple approximation for the boundaries is available. In a sampling experiment on 1,000 sequential samples, which is described in the Introduction, the test is compared with Wald's original test. The properties of the two tests seem very similar. Experiments such as these will

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probably be necessary to investigate the efficiency of this new sequential test in relation to Student's fixed sample size test. From the general properties of sequential tests one can say that the new test will, on the average, be more economical than the fixed sample size test when $\mu = 0_0$ or when $\mu = 0_0 \pm \delta\sigma$, but possibly less so for some intermediate values of μ. P. ARMITAGE.

7.—*A Purification Method for Computing the Latent Columns of Numerical Matrices and some Integrals of Differential Equations . . .* By L. F. Richardson. *Phil. Trans.*, A, **242**, 1950. Pp. 439-491.

This paper, a copy of which was kindly presented to the Library by the author, is concerned with the numerical evaluation of the latent values (eigen-values) λ_i and associated latent vectors (eigen vectors) P_i of a square matrix K of order n. In the first place it is assumed that the λ_i differ and the essential feature of the method is the repeated multiplication of a trial vector X_o by the matrix $(K - \sigma_1 I)$ where I is the unit matrix and σ_1 is a trial value in the neighbourhood of one of the latent values, λ_1. The vectors computed from the recurrence $X_{s+1} = (K - \sigma_1 I) X_s$ converge to a system of vectors which gives information about a latent root $\lambda_2 \neq \lambda_1$.

The effect of repeated multiplication by the product $(K - \sigma_1 I)(K - \sigma_2 I) \ldots (K - \sigma_p I)$ is also studied. Much ingenuity is required in the appropriate choice of the starting vector X_o and the approximations σ_i to the "unwanted latent roots" as exemplified with worked examples. Generalizations to matrices K with multiple eigen values are also discussed.

Of the statistical applications of this technique we should mention certain aspects of multivariate analysis such as Factor-, Canonical-, and Discriminant-analysis.

(Note misprint p. 442, 12th line from bottom, for K^{s+1} read X^{s+1}.)

H. O. HARTLEY.

8.—*Some Aspects of the Industrial Structure of Scotland.* By C. E. V. Leser. University of Glasgow Department of Social and Economic Research Occasional Papers: V. Glasgow, 1951. 52 pp. $8\frac{1}{2}''$. 6*s*.

This short essay is an excellent illustration of how the skilful application of relatively simple statistical methods to somewhat scanty primary statistics will yield valuable analytical results. The material used as the basis of Mr. Leser's analysis is the Ministry of Labour estimate of insured persons in each industry and in each region in 1939 and 1947. Mr. Leser tries to find out what light these statistics throw on Scotland's industrial structure as compared with the regions of England and Wales from the point of employment policy. He examines in turn the degree of specialization and diversity, characteristics of the composition of the labour force and the vulnerability to unemployment of Scotland and parts of Scotland relatively to other regions. Applying a simple index of specialization, which is identified with the sum of the positive or negative differences of the percentage importance of insured in each industry or industry group for the chosen region and for the rest of the country, he finds that the industrial structure of Scotland as a whole is much nearer to that of England and Wales than the industrial structure of Wales or any English region is to that of the rest of Great Britain. At the same time Scotland in itself shows considerable regional differences. An analysis of the composition of the labour force shows that the proportion of juveniles in industry is determined by the age structure, but the proportion of female workers in the total industrial population is largely determined by industrial structure, which thereby also determines the total size of the labour force. This tends to be high, in relation to total population, in a region containing many light industries, like London and North-West England. In Scotland there is a tendency to employ even fewer women in the heavy and even more in the light industries than in their English counterparts, and there are fewer industries in Scotland in the intermediate group which provide employment for a balanced labour force. This tendency towards segregation of men and women in different kinds of industry may make the achievement of full employment more difficult. Although specialization in Scotland is small in extent, it appears to be mainly in unfavourable directions from the economic point of view, i.e., towards greater vulnerability in a slump. Assuming that the index of vulnerability equals 100 for Great Britain, the North, Midlands, Wales, and E. and W. Ridings show the greatest vulnerability (128, 124, 122 and 110 respectively), followed by Scotland (103); London and the South East shows the least vulnerability. Mr. Leser also finds that the degree of specialization within Great Britain was generally less in 1947 than in 1939; that the Scottish specialization on very heavy industries has somewhat diminished, and that the Scottish deficiency in the very light industries has practically disappeared; lastly, in all parts of Britain vulnerability has increased between 1939 and 1947, but regional differences in vulnerability have diminished.

Mr. Leser's index of vulnerability is based on Mr. Champernowne's index of sensitivity on account of the trade cycle weighted by the number of insured persons in each industry in 1947

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for any given region. It represents a fall of employment which is to be expected in the region in case of a future slump of the 1932 pattern and dimensions, provided the employment distribution is then the same as the 1947 distribution of insured persons. The validity of such an index diminishes, however, with the likelihood of divergences of any future slump from the 1932 pattern. Indeed the change in public policy in regard to full employment was so substantial, the increase in the public control of investment so great and the shift in the relative importance of vulnerable exports, e.g., coal, so marked that one feels serious doubts about the validity of Mr. Leser's index, although its validity as an indicator of relative regional vulnerability may have been less affected than its absolute validity. It is interesting to compare it with the more realistically conceived index of Messrs. Lewis and Meyer, on regional vulnerability arising from dependence on export industries, based on similar statistics. Their index puts Scotland after the Midlands, North-West, E. and W. Ridings, N. Midlands, North, but before Wales. Mr. Leser's paper is written with admirable clarity, explaining step by step his procedure. The paper would have gained, however, by a short exposition at the start of the economic considerations underlying his whole statistical analysis.

L. ROSTAS.

9.—*Punched Cards: Their Applications to Science and Industry*. By R. S. Casey and J. W. Perry. New York: Reinhold Publishing Corporation (London: Chapman & Hall), 1951. viii + 506 pp. 9″.

This book consists of an edited assembly of 30 contributions to the use of punched cards in Science and Industry by an even larger number of authors. The contributions are arranged in 5 parts:

Part I (Punched Card Fundamentals) gives basic concepts of recording information on cards by the punching of holes, the fundamentals of systems of coding and a brief description of the commercially available systems and machines. There is a bias in favour of the hand-operated edge punched systems mainly because the full technical details of the more elaborate systems (I.B.M. and Hollerith, Remington Rand and Powers) would go beyond the limited scope of the book. The description of the latter is more superficial.

Part II (Case Histories of Punched Card Applications) gives a selection of 14 special applications to scientific and industrial problems of indexing. As an example we may quote the article by R. H. Richens, "An abstracting and information service for plant breeding and genetics" describing a "universal decimal classification" (U.D.C.) of coding the plant genetical information handled by the Commonwealth Bureau of Plant Breeding and Genetics, and the mechanization of its operations with the help of 65-column Powers Sumas cards and a sorter giving details of card lay-out filing and extraction of information required.

This article is a characteristic example of the very specialized field of application dealt with by the articles in this Part. It may be argued that such specific topics as "Specialized files for patent searching" (by W. E. Batten) are of interest only to a small group of specialists. On the other hand it is clearly only by the consideration of the full technical details of each individual problem that the question of mechanization can be properly described and discussed, and the Editors have done right in stressing the importance of this part of the book.

Part III (General and Fundamental Considerations) gives 10 articles of a more theoretical character, although some of them still deal with specific applications and resemble the articles of Part II. Whilst the latter type of contribution is usually written with the expert confidence of a specialist practitioner, one cannot help feeling that the other authors, departing from specific applications and aiming at generalizations, are somewhat vague and do not provide much of real informative value. This criticism applies in particular to Chapter 28, "Applications of punched-card methods to scientific computations". It may be unfair to expect a comprehensive treatment of this subject (on which others have written much more extensively) in 15 pages but, as the somewhat disjointed section on "Statistical Treatment" shows, even the limited space has not been properly utilized.

Part IV is entirely devoted to a detailed description of a project: Dr. E. H. E. Pietsch, head of the Gmelin Institute for inorganic chemistry at Clausthal-Zellerfeld, Germany, sets out a plan for a central mechanized information bureau in chemistry which, he suggests, should replace the present-day reference books, as these can no longer deal with the ever-growing amount of published scientific matter.

Finally, Part V gives a useful Bibliography on the uses of punched cards.

The book contains a great deal of interesting information on matters concerning punched cards. Many diverse authors have contributed to it, and as the editors have deliberately not attempted to reconcile any differences in their opinions, the book is somewhat disjointed in its structure and style.

H. O. HARTLEY.

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10.—*The Art of Asking Questions.* By S. L. Payne. New Jersey: Princeton University Press, 1951 (London, O.U.P.) xiv + 249 pp. 8½″. 24*s.*

This is the third of the Studies in Public Opinion produced under the sponsorship of the Public Opinion Quarterly. It deals with the problems that arise in framing questions, a subject which does not always receive the attention it deserves. As the author points out, a great deal of research in recent years has been devoted to improving sampling design and statistical techniques used in analysis, but many of the resulting gains in accuracy have been small. The use of bad or indifferent forms of questions may, however, lead to errors much larger than the small gains yielded by these improvements.

The discussion centres round the form of a question when considered apart from others in a questionnaire or interview, and it is mainly concerned with the choice of the right words in constructing a single question. One field excluded, therefore, is the relationship between questions and the problems that are met with in designing a battery of questions or in deciding the order in which questions should be asked. Further, since many of the readers of this review will no doubt regard the asking of questions primarily as a means of obtaining statistical data, it should be noted that all matters concerned with statistical aspects have been excluded. Thus, the book deals neither with the scaling and rating of answers nor with the statistical analysis and reduction of data.

These remarks should not, however, be interpreted as a criticism of the author, who explains at the outset that he has deliberately excluded these topics from the present study. On the contrary, the decision to restrict the field in this manner is more than justified. He has thus been able to give a full and authoritative treatment of a neglected subject, and still keep the book within reasonable limits. The book brings together in one place many important points and hints on question design which otherwise could only be found by an extensive search through the literature on this subject. Most of the examples relate to questions of opinion, knowledge, attitude or intention, but his criticisms and advice are of wider application. Examples of the problems that arise in asking questions about facts will be found throughout the book, but their number could with advantage have been increased. A study of them will show that asking for factual information, whether by questionnaire or interview, is full of pitfalls for the unwary.

The book is well written; in fact, it reads so smoothly that on first reading one is likely to under-estimate the care with which it has been compiled. Mr. Payne has succeeded in conveying in a very simple manner the basic ideas, without becoming involved in a discussion of semantics. Finally, the reviewer would like to single out two features for special praise: firstly the list of 1,000 frequent and familiar words, and secondly, the discussion of problem words.

W. F. F. Kemsley.

11.—*Industrial Censuses in Western Countries: Report of a Group of Experts.* Paris: O.E.E.C. September, 1951 (London, H.M.S.O.). 69 pp. 9¼″. 7*s.* 6*d.*

In 1950 the O.E.E.C. appointed a mission of 16 experts from 9 member countries "to gain first-hand knowledge of European practices and to pool and compare experiences" on "the methods and general problems involved in establishing and conducting national industrial censuses". The mission (chairman, Dr. C. O. George of the Board of Trade) visited in September and October, 1950, four countries (Denmark, France, the Netherlands and the United Kingdom). Its report summarizes the practices in these countries, deals with some of the problems involved in initiating such censuses and discusses various matters in which international comparability is desirable. As France has never succeeded in holding an industrial census, the five tables in which the branches of industry covered, and the questions asked are compared, are limited to three countries. In a final chapter the mission recommends that all member countries of O.E.E.C. should if possible hold an industrial census in an agreed year (1953 is suggested), that a common list of industries should be adopted (the U.N. standard classification is suggested), and that agreement should be reached on the scope of such terms as gross output, net output, work given out, and units of weight and volume. The limitation of the information to so few countries hardly justifies the title. Moreover the value of this very general report is now diminished by the fact that the United Nations Statistical Commission in May, 1950, and in May, 1951, considered a comprehensive report on this subject, and the meeting of European Statisticians (called by the Economic Commission for Europe) in September, 1951, had before it a report analysing in detail the position in 18 European countries. Both these bodies made recommendations in many cases similar to those of the mission. Unfortunately none of them agreed on the uniform base year, and countries contemplating the compilation of these basic industrial statistics can take their choice of 1952, 1953, or 1955!

J. W. Nixon.

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12.—*United Nations, Department of Economic Affairs. Labour Productivity of the Cotton Textile Industry in Five Latin-American countries.* New York, 1951 (London, H.M.S.O.). 293 pp. 11″. 22*s.* 6*d.*

This highly technical study of the cotton spinning and cotton weaving industries of Brazil, Chile, Ecuador, Mexico and Peru was made by the staff members of the Economic Commission for Latin America with a view to determining the factors influencing labour productivity. A representative sample of mills was selected, differing in size, degree of modernity, characteristics of production, and location; and in each of these, labour productivity (kilograms per man-hour) was measured, process by process, for the greatest possible number of products. The values of productivity were expressed by means of curves, and the level of productivity of a given industrial sector was also expressed by means of a curve, the formula of which was determined by the method of least squares, taking into account all the individual productivity observations of the sector under consideration. Separate data are given for old mills and modern mills, the distinction between these being based on the type of machinery (e.g., multiple-process pickers and standard draft systems in the former and one-process pickers and high draft systems in the latter).

In order to make a comparison of productivities and to determine the magnitude of productive deficiencies, a number of standard mills (144) were designed, assumed to be operating with maximum efficiency; the productivities of these mills covering six sizes in spindles, six counts of yarn, six sizes in looms and six types of cloth were obtained by calculation, and the computed productivities of these standard mills compared with those of the mills in the sample. The technical methods adopted and the full data for each of these standard mills are given in an annex.

The relation between average labour consumption, i.e., the reciprocal of the above measure of productivity and that of a modern standard mill, was expressed as a ratio, called "total influence", and this was broken down into its principal components: the influence of type of equipment, the size of the mill, and the operation of the mill. For the last component a sub-sample of mills was taken, and the processes examined in great detail so as to estimate the influence of such factors as differences in the output of machinery, excess of labour and speed of machinery.

The result of these calculations is to show that for all countries together in old mills manhours per kilogram is 5 times (index 505) greater than that which could be expected under the best conditions of modernity of equipment, size of equipment and administration. For modern mills the index is 182. (The former index varies from 369 in Mexico to 1,210 in Ecuador and the latter from 137 in Mexico to 241 in Chile.) The "breakdown" of these total figures into the different factors was as follows:—

	Size	*Equipment*	*Operation*
Old mills	106	206	231
Modern mills . . .	113	100	161

(The product of these factors, expressed as unities, equals the above figures, expressed as unities.)

The study concludes with a series of recommendations for improving the backwardness of textile mills, demonstrated by this investigation, which depends in part on the low degree of economic development in these countries.

Presumably the data in this report relate to a recent date, but the absence of any information on when these investigations took place and over what periods of time they were conducted is a serious omission in an excellent and thorough study of the subject. J. W. Nixon.

13.—*Conference on Business Cycles* held under the auspices of the Universities—National Bureau Committee for Economic Research. Edited by Gottfried Haberler and others. New York: N.B.E.R., 1951. xii + 427 pp. 9″. $6.00.

This volume contains the papers delivered at a conference on business cycles held in New York in November, 1949, and, no less important, the major contributions to the discussions. The papers have subsequently been revised, and the reader will by no means find this volume out of date. On the contrary it gives a good idea of the current trend in American thinking on econometric research.

Among the eleven papers two will be of interest to general economists. First, we must be grateful for another paper by Schumpeter (which he was unable to revise before his death) on "The historical approach to the analysis of business cycles". This gives a very balanced account of the way research in economics should be conducted. His remark (on p. 154) that the Kitchin cycle "may possibly be explained by some such scheme as Metzler's inventory cycle" should reassure readers that Schumpeter's historical approach embraces most other approaches. Secondly, there is the stimulating paper by Professor Haberler on "Business cycles in a planned economy" (a quotation may whet the reader's appetite: "There is surprisingly little difference between the methods of economic control in Nazi Germany and Labour Britain. In fact Schacht seems to

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have been much less of a convinced Schachtian than his British imitators and admirers"; p. 382). This paper is commented on by Bergson with reference to the Russian type of economic system.

For the econometrician, however, it is the paper by Carl Christ on "A test of an econometric model for the United States, 1921–1947" that will put this volume among the most important to appear in recent years. In the opinion of the reviewer this paper brings the debate on the value of the method of simultaneous equations in econometric applications significantly nearer its close. It may be useful to summarize the development of this method of analysis. In 1943 Haavelmo in his article in *Econometrica* pointed out that observations of economic phenomena were generated by a system of relationships, and that they should therefore be regarded as jointly determined variables. This is in contrast to the state of affairs in the natural sciences, where the experimental method implies that there is only a single dependent variable whose variations are to be explained by those of the independent variables. The classical least squares approach in econometric applications is based on the assumption that there is only one dependent variable, and it was therefore argued that new techniques had to be developed to generalize the classical result to the case where there were a number of jointly determined dependent variables.

The plea that each science needed its own methods encouraged new if formidable estimation procedures. Indeed the "best" of these procedures—termed the full information method—has never been applied to a system of more than three equations because of computing expense. The limited information method is less perfect but easier to apply; even so, it was not till 1950 that we were presented with the *full* details of Mr. Klein's system of fifteen equations describing the U.S. economy in the period 1921–41.

The present paper by Mr. Christ shows how this model may be subjected to a number of tests. The model was first revised to include the observations for 1946 and 1947, and then a forecast was made for the 1948 values. Of the several tests applied by Mr. Christ, one tested the observed 1948 values for consistency with the model, that is, whether the discrepancies between the observed and computed values for 1948 could have arisen by chance at a given probability level. In another test the 1948 predictions of the model are compared with a "naive" prediction, for example, that the 1948 values are the same as the 1947 values.

Neither of these tests, of course, can be conclusive. In particular, success in the first test may only mean that the 1948 values fit the equations no worse than do the earlier values on which the estimates of the parameters are based. In fact, however, most of the equations are rejected by one test or another, and the result that the model's predictions are no better than the "naive" predictions for about half the equations may be considered as disappointing.

Klein in his contribution to the discussion rightly points out that the post-war series which were used in revising the model were not consistent with the estimates of earlier values of the series, and this test of econometric forecasting (which, in any case, is only based on one year's forecasts) cannot therefore be taken very seriously.

We are also presented with single equation (least squares) estimates for comparison with those of the simultaneous equations approach and these may be regarded as leading to fairly firm conclusions. In no case does the more involved method yield obviously superior estimates. Indeed, if we may generalize on the basis of the calculations now before us it appears that (1) when the estimates of the simultaneous method are at all acceptable they do not differ significantly from those given by the single equation approach; and (2) the single equation estimates appear to be more stable with respect to the introduction of a single bad observation, as is made clear by the remarkable example on pp. 86–7.

There are three questions that will occur to the interested onlooker. First, why is it that these new methods do not in practice show their expected advantages? The answer is obviously complicated, but in brief it appears that the gain which arises from taking into account the effects of interdependence is outweighed by the loss due to the unrealism of the other assumptions involved. Two of these assumptions are that there are no errors of observation in the variables, and that errors in any one equation are, in general, independent of the large number of variables that enter into the whole system of equations. The whole matter, however, requires further investigation.

Secondly, why is it that so much research effort has been devoted to this line of investigation with so little practical result? The answer here is easier; it appears to the reviewer to be due to a predilection among the Chicago school of thought for speculative rather than empirical research, with the consequence that there has been too little exploratory testing of intermediate results.

The third question is, along what lines should econometric research proceed in the future? This is the question that underlies much of the discussion reported in the first half of this volume. The comments of Friedman, Koopmans and Marshak are particularly interesting: the general recommendation that further research should be confined to intensive examinations of small sectors of the economy reveals a pleasing agreement, at least in theory, with the views of those working in this field in other parts of the world.

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It would be unfair to end this review without referring to the excellent "Studies in investment behaviour" by Klein in the latter portion of the book. Classical single equation methods are used in estimating the demand for investment in railways and electric light and power. The use of cross-section material in this connection is noteworthy, as is also the result that the interest elasticity for the mature railway industry is less than one, but for the still expanding electricity industry it is nearly three. These "Studies" should convince the reader of the soundness of the approach commended in the last paragraph.

While the book may be expensive for English readers, it is well produced and deserves the attention of all who are interested in current econometric thought.

S. J. PRAIS.

14.—*The Economics of National Insurance.* By Alan T. Peacock. London: William Hodge, 1952. 126 pp. $8\frac{1}{2}''$. 8*s.* 6*d.*

This important book serves three main purposes. In the first place it brings together in compact form a multitude of economic statistics relating to social security. Secondly, it demonstrates with cogency how National Insurance operates as an instrument of income redistribution comparable to food and housing subsidies. Thirdly, it points out the administrative wastefulness of having several different machineries for redistributing income, and it supports a single comprehensive scheme, of the type originally evolved by Lady Rhys-Williams, in which National Insurance, National Assistance, Family Allowances and Income Tax Allowances would all be encompassed.

In each of his three aims the author has scored a signal success, and the result is a book which should be read by all students of either social security or public finance. He surveys National Insurance not as an isolated activity of government, but as an integral part of the national economy which cannot be divorced from other aspects of fiscal policy. There are times, it is true, when the reader may feel that earlier thought on the subject is too readily overlooked, and that the author is advancing his thesis as though the exposition of social insurance as a form of income redistribution represented a recent change in basic concepts. In actual fact, this viewpoint has been current in actuarial thought from the time when social insurance in this country was first mooted. Thus in a paper on "Collective Assurance" read before the Institute of Actuaries in 1892, Ralph Price Hardy said:

> "The financial effect of the Collective System is to distribute the burthen of purchase over the whole population, lightening the pressure upon the older and transferring the same to the younger."

In the discussion which followed, the contrasting arguments on the question whether social insurance should be financed by contributions or by taxation were elaborated with some thoroughness, and it is remarkable how fresh this discussion reads to-day despite the intervening passage of sixty years.

Mr. Peacock's references to the actuarial principles on which the National Insurance scheme is based are, perhaps, the weakest part of his book. Nowhere is it made sufficiently clear to the reader that neither the National Insurance Fund nor the National Insurance (Reserve) Fund is in any real sense equivalent to the actuarial reserves which are maintained by assurance companies or by trustees of superannuation schemes. In fact National Insurance is virtually unfunded, the reserves held being no more than an inheritance from the old National Health Insurance scheme augmented by small annual balances from the working account of the existing scheme. Thus the contrast between social insurance and private insurance is even stronger than Mr. Peacock indicates.

It is, of course, well known that the National Insurance contributions paid by employers and insured persons are together inadequate to provide the benefits receivable and that the balance of cost falls on the Exchequer (i.e., the taxpayer). Mr. Peacock rightly emphasizes this fact as another instance of the contrast between the national scheme and private insurance. Once again, however, the argument is even stronger than it superficially appears. At the date of initiation of the National Insurance scheme a vast army of beneficiaries immediately acquired vested interests for which they had paid either nothing at all or the merest fraction of the real cost. Moreover, because we are living in an inflationary economy, it has become clear that enlargements of benefit will be granted from time to time in reflection of the rising cost of living—and each such increase represents a gift to the beneficiaries to be paid for by future generations of taxpayers.

The plain fact is that Hardy, in the quotation cited above, was absolutely right in his description of the nature of social insurance. Its purpose is to transfer purchasing power from the young and active to the sick and the old. Each generation of workers pays, not for its own future retirement pensions, but for the pensions currently being paid to the retired section of the population living at the time. This being so, it is proper that the means of raising the necessary cost of

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National Insurance benefits should be brought under review, and that schemes of the kind first advanced by Lady Rhys-Williams, proposing a wholesale simplification of the existing machinery for income readjustments, should be given the fullest consideration. The exposition in Mr. Peacock's final chapter of one such scheme is excellent in every way, and demonstrates with the utmost clarity how a simplified administrative machinery could achieve results in income redistribution virtually identical (except where it has been deliberately adjusted in favour of the lower-paid worker with a family) with what is at present achieved by far more cumbersome and expensive methods.

R. D. CLARKE.

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STATISTICAL NOTES

(1) British Official Statistics

The interim index of retail prices published by the Ministry of Labour and National Service which stood at 133 (prices at June 17th, 1947 = 100) in March rose to 135 by April 8th and remained at the figure at May 22nd. The increase in April was due mainly to a rise in the prices of bread, flour, fish and vegetables and to a rise in many local rates. Separate figures on the same basis for different groups of commodities are not available, but the following are the figures based on January 15th, 1952 = 100.

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Household Durable Goods*	*Miscellaneous Goods*	*Services*	*Alcoholic Drinks*	*Tobacco*	*All Items*
Weights:	399	72	98	66	62	44	91	78	90	1,000
Mar. 11th	100·8	100·2	100·0	100·5	99·7	101·3	100·3	100·1	100·0	100·1
Apr. 8th	103·9	102·1	99·9	101·5	99·8	102·5	102·8	100·1	100·0	102·2
May 13th	104·4	102·3	99·1	99·6	99·4	103·4	102·7	100·8	100·0	102·2

The Ministry of Labour index of weekly wage-rates which was 128 at the end of March and April rose to 129 in May. The principal industries in which wages were higher at the end of May than two months earlier were iron and steel manufacture, furniture and boot and shoe making, and workers engaged in unlicensed places of refreshment, meat distribution and brick making.

The total working population and the numbers in civil employment in the three months ended April were as follows:

(*Thousands*)

	Total Working Population			*Numbers in Civil Employment*		
	Males	*Females*	*Total*	*Males*	*Females*	*Total*
Feb., 1952	16,027	7,403	23,430	14,954	7,202	22,156
Mar., ,,	16,031	7,413	23,444	14,947	7,176	22,123
Apr., ,,	16,049	7,429	23,478	14,956	7,176	22,132

The number of persons on the unemployment registers of the Employment Exchanges rose by 34,900 in April. There was an increase of 38,000 in textiles and a slight fall in all other industries combined. In May there was a drop in the total figure of 400, although textiles showed a further rise of 7,000. The total of 467,000 unemployed at May 12th represented 2·2 per cent. of the estimated total of employees. The percentages in the separate regions ranged from 1·0 in the Midlands and 1·2 in London and the South-East, to 3·1 in Scotland and 5·1 in the North-West.

The following is a sex analysis of the figures:

Numbers of Unemployed Persons on the Registers of Employment Exchanges.

Date	*Men and Boys*	*Women and Girls*	*Total*
March 17th, 1952	229,974	203,000	432,974
April 21st, ,,	242,568	225,303	467,871
May 12th, ,,	235,167	232,278	467,445

Of the total of 467,445 at May 12th, 147,089 were temporarily stopped, 96,631 had been unemployed for not more than 2 weeks, 86,630 for 2 to 8 weeks and 137,095 for over 8 weeks.

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The number of insured persons absent from work owing to sickness, including self-employed as well as employed, was 937,200 in March, 780,300 in April and 811,000 in May. The number of employed persons absent owing to industrial injury was 59,900 in March, 48,600 in April and 55,700 in May.

An age analysis of employed persons based on a sample of the ledger accounts of the Ministry of National Insurance was published in the June issue of the *Ministry of Labour Gazette*. It shows that at May, 1951, the broad grouping was as follows:

Age-group	*Per cent of total*	
	Males	*Females*
Under 20	7	17
20 and under 40	44	45
40 and under 60 (females) 65 (males)	45	34
60 (females) and 65 (males) and over	4	4
	100	100

Compared with 1950 there was a slightly higher proportion of both males and females aged 40 and over. Some statistics of wastage can be obtained by comparing the figures for particular ages with those for the immediately lower age in 1950. For example, the effect of reaching pensionable age is shown by comparing the number of employed men aged 65 in 1951 with those aged 64 in 1950. The figure fell from 138,000 to 97,000, a drop of 30 per cent. Again, the wastage of women aged 19 to 29, due largely to retirement on marriage, ranged from 2·7 per cent. at the age of 28 to 8·2 per cent. at 23 and 8·9 per cent. at 22. The proportion of married women in employment is shown, on the basis of the sample, to be about 3 million, or 43 per cent. of the total female employees.

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(2) Other Statistics

The scope of the eleventh issue of the *I.L.O. Year Book of Labour Statistics*, 1949–50, follows closely that of the previous issue (see this *Journal*, Vol. CXII, Part III, 1949), and only the principal changes in this volume therefore need be mentioned.

The statistics of employment, hours of work and wages are now given separately for four main economic activities (manufacturing, mining, construction and transport); those of industrial disputes are given by industries; and the statistics of social security, introduced for the first time in the previous issue, have been considerably improved and expanded to cover 46 countries (instead of 31). Some new countries (mostly "non self-governing") have been introduced, and one country—Hungary—omitted on the ground that its government "indicated that the data available no longer reflected conditions in that country". In spite of this curious statement, many of the suppressed statistics are given, "as furnished by the I.L.O.", in the subsequently issued *U.N. Statistical Yearbook*, 1951.

The preface states that the volume "presents the principal statistics relating to labour in some sixty countries in all parts of the world". This is an overstatement, since no statistics (except population) are given for one important part of the world, the U.S.S.R.; it is also an understatement since the volume covers also about thirty non self-governing territories. These are omitted from the standard "List of Countries" at the beginning of the volume, and also from the index of "Countries appearing in each Table" at the end of the volume, both of which are confined to self-governing countries (even so, they omit China, Ecuador and Iraq). As a special effort has been made to cover non self-governing areas (especially for wages and retail prices), and their statistics are superior in some cases to those of some self-governing countries, it is unfortunate that nowhere are indications given of the true scope of the volume. This should be rectified in future issues.

The comprehensiveness of this new issue both as regards subjects covered, countries covered and years covered (annual figures are given usually for 1937 to 1950, and monthly and quarterly figures up to June, 1951), the excellent arrangement of the tables and the valuable introductory statements to each Section, make it a standard book of reference, indispensable for the study of labour conditions in different countries.

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As this "year book" has not appeared at yearly intervals since 1942 and as figures are given, in some tables, for 1951, the title of the present issue is inappropriate. Readers looking for information on the cost of living will no longer find this familiar term, as it has been replaced throughout by the term "consumer prices" (index numbers), except on the cover of the book, and in the *U.N. Statistical Yearbook*, 1951, which retain the term "cost of living".

Five independent experts (including Mr. G. D. A. MacDougall from the United Kingdom) were requested by the Secretary-General of the United Nations to formulate "practical ways" of reducing the international impact of economic depressions. Their report, *Measures for Internal Financial Stability* (U.N. Department of Economic Affairs, New York 1951), is a sequel to an earlier report on "National and International Measures for Full Employment" (1949), which was also the work of a group of experts, some of whose recommendations (e.g., that creditor nations should maintain their level of external payments irrespective of fluctuations in internal activity) have perhaps been regarded as "impracticable". The present report, while starting from the same economic analysis, criticizes the recommendations of the earlier group of experts, and concentrates its own remedies on—

(i) international commodity arrangements of a non-restrictive kind to even out short-term fluctuations in demand and prices; such arrangements might incorporate long-term contracts, multilateral quotas or buffer stocks, but the experts regard agreement on quantities as a sounder method of stabilization than any form of international price control;

(ii) an increase in the capacity of the International Bank to lend for investment, especially in periods of depression when private investment and export proceeds in primary producing countries drop off;

(iii) providing the International Monetary Fund with financial resources on a scale more adequate to enable the Fund to alleviate temporary difficulties of member countries.

Report of Proceedings, Conference of British Commonwealth Statisticians, 1951 (Commonwealth Government Printer, Canberra, 1952). Unlike the first two conferences of statisticians—the first held in London in 1920 and the second in Ottawa in 1935—the Canberra meeting did not pass a series of formal resolutions aimed at improvement of official statistics but decided instead to present an extended summary of the views expressed, whether or not there was substantial agreement. The range of topics discussed was very wide: industrial, commodity and occupational classifications; index numbers of external trade and the terms of trade; national income, capital formation and production indexes; the use of price indexes as deflators; retail price indexes and family budget enquiries; retail trade and census of distribution; agricultural statistics; developments in census taking and applications of sampling methods.

The Report is itself a summary of the Proceedings. Most statisticians will find something of interest, as is illustrated by reference to the main points of the agenda of the meeting. There are good discussions of the definition and a central register of industrial establishments; of the problems of seasonal variations and quality changes in retail price indexes; of the question of the adoption of the Standard International Trade Classification of the U.N.; of the choice of indicators in production indexes and of estimates of capital formation; of the "prices" to be used in external trade indexes; of the organization of agricultural censuses or surveys; of the use of sampling techniques in such surveys as those of agriculture, the labour force and family budgets.

The Government of Australia is to be congratulated, not only on its initiative in convening this conference, but also on the care and expedition displayed in publishing this Report.

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CURRENT NOTES

The trustees of the Houblon-Norman Fund, on the recommendation of their Advisory Committee, have made the following awards for 1952/53.

Fellowship.—Mr. E. W. J. Kerridge, Assistant Lecturer, University of Nottingham, "The History of Ley Farming, particularly in Midland England, in the XVI, XVII and XVIII Centuries".

Research Grants.—Mr. A. Birch, Research Student, University of Manchester, "The Economic History of the British Iron and Steel Industry, 1784–1879"; Mr. D. J. Darby, Bank Official, "The London Banks in the Bank Restriction Period"; Mr. R. J. Hartridge, Teacher, South London Secondary Central School, "The Development of Industry in London South of the Thames from 1700 to 1850"; Dr. G. P. Insh, C.B.E., D.Litt., Historian, "The Financial Activities of William Paterson"; Mr. J. Johnston, Lecturer, University College, Bangor, "Cost-Output Relationships in a Sample of Firms from different Industries"; Mr. J. Lanner, Lecturer, University College, London (renewal), "Banking in Post-War Germany"; Mr. E. C. Parsons, Civil Servant, "Mobility of Labour and the Distribution of Industry"; Mr. F. M. L. Thompson, Assistant Lecturer, University College, London, "The Social and Economic Background of the English Landed Interest, 1840–70"; Mr. S. Wainwright, Financial Journalist, "20th Century Development of Swiss Financial Institutions".

An offer of awards for 1953/54 will be made early in 1953. Further information may be obtained from the Secretary, Houblon-Norman Fund, c/o Bank of England, London, E.C.2.

Fellows will have noted with pleasure in the Birthday honours list of June, 1952, the award of a knighthood to the President, Professor R. A. Fisher, F.R.S.

Fellows will also wish to congratulate Professor R. G. D. Allen on his recent election to Fellowship of the British Academy.

Dr. George B. Wilson, who died on June 7th, 1952, at the age of 88, was one of the Society's oldest Fellows in terms of Fellowship as well as of age, having been elected in 1916. He graduated in law at London University in 1887, but immediately thereafter devoted his attention to the cause of temperance, which he served with unremitting zeal for 40 years. In the course of his life's work he became an outstanding authority on the statistics of his subject and was a redoubtable opponent in the interests of temperance. In 1940 he obtained a Ph.D. degree of London University for his book entitled *Alcohol and the Nation*. Much earlier, in 1911, he was awarded the Howard Medal of the Society for his essay on "Variations in the Consumption of Intoxicants", and was in fact the last Fellow to receive this distinction.

Dr. M. J. Elsas, who died at Hampstead on April 18th, 1952, at the age of 70, had been a Fellow since 1934. He had long enjoyed an international reputation in statistical circles and in him the Society has lost a valued member. A paper by Dr. Elsas on *The Problem of Estimating Housing Needs* was communicated in his absence to the Study Section of the Society during his final illness. Sir Arthur Bowley writes: Before Dr. Elsas left Germany at the time of Hitler's rise to power his statistical activities were already international. Doctor of Staatwissenschaft at Frankfurt a/M, he not only contributed articles on statistical subjects to the *Frankfurter Zeitung* but also, about 1919, launched there a new venture of considerable importance, viz., a weekly cost of living index. The German section of the *Manchester Guardian Reconstruction Supplements* edited by J. M. Keynes, 1922, was his work, and so, from 1923 to 1939, was the German section of the *London and Cambridge Economic Service*. He also wrote for the International Committee on the History of Prices two monumental volumes entitled *Einer Geschichte Der Preise und Lohne in Deutschland vom Ausgehenden Mittelalter biz zum Beginn des Neunzehnten Jahrhunderts*.

After settling in England (he was married to a niece of Mr. Barnard Ellinger, a former Vice-President of the Society) Dr. Elsas was engaged on an inquiry for the Population Investigation Committee, the results being published in two books on *Housing and the Family*. During the early years of the war, working under Professor Bowley's advice, he contributed Chapter I, on definitions of national income, of *Studies : National Income*.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

Accounting Research—

April 1952—Solution of funds statement problems—history and proposed new method: *R. H. Gregory* and *E. L. Wallace*. A distinction between "profit" and "income": *L. Goldberg*. Profits of the year—or of last year?: *H. Norris*. A theory of cost and cost accounting—I: *G. D. de Swardt*. Accounting researcu—an international function: *A. A. Garrett*.

Advancement of Science—

March 1952—Social services expenditure during the last 100 years: *J. Stirling*.

Biometrika—

June 1952—Moment coefficients of the *k*-statistics in samples from a finite population: *J. Wishart*. Moment-statistics in samples from a finite population: *M. G. Kendall*. Some exact tests in multivariate analysis: *E. J. Williams*. The construction of balanced designs for experiments involving sequences of treatments: *H. D. Patterson*. Multi-factor designs of first order: *G. E. P. Box*. Tests of significance in canonical analysis: *F. H. C. Marriott*. The interpretation of interactions in factorial experiments: *E. J. Williams*. On sampling from a population of rankers: *A. S. C. Ehrenberg*. Least-squares estimation of location and scale parameters using order statistics: *E. H. Lloyd*. Regression, structure and functional relationship: *M. G. Kendall*. On the concurrence of a set of regression lines: *K. D. Tocher*. A sampling test of the χ^2 theory for probability chains: *M. S. Bartlett*. On mathematical analysis of style: *W. Fucks*. Comparison of two approximations to the distribution of the range in small samples from normal populations: *E. S. Pearson*. The covering circle of a sample from a circular normal distribution: *H. E. Daniels*. The frequency justification of certain sequential tests: *G. A. Barnard*. Experimental designs for serially correlated observations: *R. M. Williams*. The time intervals between industrial accidents: *B. A. Maguire*, *E. S. Pearson* and *A. H. A. Wynn*. The estimation of death-rates from capture-mark-recapture sampling: *P. A. P. Moran*. Tables of percentage points of the "Studentized" extreme deviate from the ample mean: *K. R. Nair*. Extended and corrected tables of the upper percentage points of the "Studentized" range: *J. M. May*. On the distribution of "Studentized" range: *K. C. S. Pillai*. Note on a certain family of discrete distributions: *J. S. Maritz*. Some properties of runs in smoothed random series: *A. M. Grant*. An approximation to the symmetrical incomplete beta function: *J. H. Cadwell*. The distribution of quantiles of small samples: *J. H. Cadwell*. On a correction term in the method of paired comparisons: *J. A. van der Heiden*.

Economica.

May 1952—Marshall's principles of economics in the light of contemporary economic thought: *C. W. Guillebaud*. The effects of income-redistribution on aggregate consumption with interdependence of consumers' preferences: *H. G. Johnson*. The economists' description of business behaviour; *G. F. Thirlby*. The inequality of incomes in the United Kingdom: *E. C. Rhodes*. Unemployment in Belgium and full employment policy: *W. Robertson*. Cost curves for electricity generation: *K. S. Lomax*.

Economic Journal—

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Manchester School of Economic and Social Studies—

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UNITED STATES—

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DENMARK—

Nationalφkonomisk Tidsskrift—

Vol. 90, Parts 1, 2—Om realindkomst: *P. N. Rasmussen.* Økonomik historieskrivining om nyere tid i økonomisk teori og statistik: *P. Milhφj.*

GERMANY—

Mitteilungsblatt für Mathematische Statistik—

Vol. 4, Part I—Zum Ausreisserproblem: *U. Graf* and *H-J. Henning.* Die multiple Faktoranalyse: *H-J. Grüneberg.* Über das Ausgleichen einer fehlerhaften linearen Punktreihe bei korrelativer Verknüpfung der Messfehler: *K. Stange.* Mathematisch-statistische Probleme in den Forstwissenschaften: *M. Prodan.*

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International Labour Review—

May 1952—Input-output analysis as an aid to manpower: *J. Burtle.*
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LIST OF ADDITIONS TO THE LIBRARY

Since the issue of Part II, 1952, the Society has received the publications enumerated below.

I.—OFFICIAL PUBLICATIONS

(a) United Kingdom

Board of Trade. Britain's shops: a statistical summary of shops and service establishments; prepared by the Statistics Division . . . London, H.M.S.O., 1952. vi, 59 pp. 10¾″. 3*s.*

Colonial Office. Digest of colonial statistics. No. 1. March-April, 1952. London, H.M.S.O., 1952. 68 pp. 11″. 3*s.* 6*d.*

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Ministry of Health. National Health Service. Hospital costing returns year ended 31st. March 1951. Part I. Regional hospital boards and hospital management committees in England and Wales. Part II. Boards of governors of teaching hospitals in England and Wales. London, H.M.S.O., 1952. 123 pp. 12¾″. 10*s.*

Hospital and specialist services England and Wales: statistics for the year ended 31st. December 1949. London, H.M.S.O., 1952. [ii], 300 pp. 12½″. 20*s.*

Ministry of Labour and National Service. Interim index of retail prices: methods of construction and calculation (revised edition). London, H.M.S.O., 1952. 35 pp. 8½″. 1*s.* 3*d.*

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Belgium

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Canada.

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Denmark

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Journal of the Royal Statistical Society

SERIES A (GENERAL)

PART IV, 1952

Statistics of Tins and Cans

By John Ryan

[Read before the Royal Statistical Society, May 28th, 1952, Mr. H. Campion, C.B., Vice-President, in the Chair]

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1. INTRODUCTION

THIS paper attempts to present the statistics of the tin and can manufacturing industry. It begins with a consideration of its main raw material, tinplate; it presents such few statistics as are published on cans and their manufacture, and makes a number of estimates to fill gaps in those statistics. It proceeds to consider statistics of the industry (food canning) which forms the largest single outlet for tinplate containers, and it makes a brief survey of the other industries which use tins and cans. Finally it attempts to make certain forward projections on the future supply and demand of tinplate, since it is tinplate which has in the last seven years, almost throughout the whole world, been the limiting factor in the development of those industries with which this paper is primarily concerned.

Although the subject of tins and cans may appear at first sight to be a specialized one, I make no apology for bringing it for the first time to the attention of the Society. The industry is closely connected with a wide range of other industries. In its base material it is dependent on a basic industry, steel, and its end-products serve a large proportion of the whole range of consumers' goods industries.

There have been references to the tinplate industry in Mr. Birkett's two papers, "Iron and steel trades during the war" (1920, vol. lxxxiii) and "Iron and steel industry since the war" (1930, vol. xciii), and also in Mr. R. Shone's papers, "The iron and steel development plan" (1947, vol. cx) and "Statistics relating to the iron and steel industry" (1950, vol. cxiii).

In his presidential address Sir Alfred Flux (1930, vol. xciii) referred to the consumption of canned fish, condensed milk and preserved fruit and vegetables, but it is a sign of the relatively recent growth of the canning industry that in the previous paper to the Society, before the address of Sir Alfred Flux, dealing primarily with the food supply of the United Kingdom ("The Nation's food supply" by Sir Henry Rew, 1913, vol. lxxvi), there is no reference to canned food at all.

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I should like to mention here three works on tinplate—*The Tinplate Industry* by Professor J. H. Jones (1914), *Chronology of the Tinplate Works of Great Britain* by Mr. E. H. Brooke (1944) and Appendix (1949), and *Tinplate* by Mr. W. E. Hoare and Mr. E. S. Hedges (1945). I am indebted to each of them for providing valuable background material for the section of this paper which deals with tinplate.

I am also indebted to the International Tin Study Group, from whose statistical bulletins I have drawn many of the statistics in this paper concerning the production and consumption of tinplate outside the United Kingdom.

2. TINPLATE

(a) *Definitions*

(i) *Tinplate, Blackplate and Terneplate*

Statistical difficulties in this field frequently arise from a looseness of definition of the terms tinplate, blackplate and terneplate.

Tinplate consists of a sheet of rolled mild steel (normally about 0·01 in. thick) coated with a thin layer (normally less than 0·0001 in.) of pure tin.

The same rolled mild steel sheet without the coating of tin is either called "blackplate" or (as in Census of Production (1948) schedule) "tinplate base, uncoated" or, simply, "tinplate base", or (when subjected to cooling processes in which oxydization is minimized) "tinplate base, white-to-edge".

When this rolled mild steel sheet is coated with a mixture of lead and tin (usually 75 per cent. lead to 25 per cent. tin) it is called terneplate.

The term tinplate is frequently used to cover generically both blackplate and terneplate, as well as tinplate proper, and this use gives rise to statistical difficulties to which I shall refer later. In this paper I shall only use the word tinplate in this generic sense where there is no risk of ambiguity.

Tinplate is produced by two methods:

(a) *The hot-pack rolling process.*—This is a manual process and is the traditional method of manufacturing tinplate. It involves passing and re-passing heated steel bars between rollers by hand, and production is limited by the human capacity to perform this very heavy work.

(b) *The continuous cold-reduction process.*—The steel is rolled in one continuous strip weighing about 15 tons. In the new British plant, to which I shall refer later, it is rolled hot at Margam to a thickness of about 0·07 in., and then transported to Trostre for further cold-rolling to a thickness of, say, 0·012 in.

The tin coating may be applied either by dipping individual sheets in a bath of molten tin or (when the steel base has been rolled in a continuous strip) by electrolytic deposition.

(ii) *Basis Box*

The basis box is the standard unit of area in the tinplate industry throughout the world. It is defined as 31,360 square inches, which was the area of the traditional "basis box" of 112 sheets, each 20 in. by 14 in.

(iii) *Substance*

The "substance" of tinplate is the measure of its thickness. It is defined in terms of the weight of a basis box (i.e., 100 lbs., 90 lbs., etc.). The standard substance (for which prices are quoted) in the United Kingdom is 108 lbs. (frequently called I.C.), and is equivalent to a thickness in modern tinplate of 0·0119 in. The standard substances in the United States are (for domestic use) 100 lbs. and (for export) 107 lbs. Although "rule-of-thumb" ratios are frequently used in the trade to convert "basis boxes" into "tons", the fact that some statistics are compiled in units of area (basis boxes) and others in units of weight (tons) is another potential source of statistical misunderstanding. During 1951 the overall "basis box/ton" ratio for United Kingdom production of tinplate, blackplate and terneplate was 21·97, i.e., an average substance of 102 lbs.

(iv) *Tin Coatings*

The thickness of the tin coating on tinplate is measured in terms of the weight of tin on the surface of a basis box. It is conventional in the United Kingdom to prefix the letter C before the

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weight in ounces; thus "C16" (which is the standard coating on which prices are quoted) represents 16 oz. of tin per basis box, and is equivalent to 0·0000606 in. thickness of tin coating on each side of the sheet.

In the United States it is more customary to quote the coatings in pounds per basis box, and to define them on a "pot-yield" basis, i.e., the amount of tin required (including normal processing losses) to manufacture a basis box of tinplate. Thus British tinplate with a 20-oz. coating carries a coating weight of 20 oz. of tin, whereas the corresponding American product (1·25 lb. tinplate) carries a coating weight of about 17·5 oz. This difference in definition of coatings impairs the comparability of U.K. and U.S.A. statistics.

(b) *Statistical Sources*

Tinplate is fortunate in being well-documented statistically on an international basis. The International Tin Study Group in their *Monthly Statistical Bulletins* and their *Year-Book*, publish statistics of output of the main producing countries, of trade between the main producing and consuming countries, and of apparent consumption for each of 55 countries.

Herein, however, lies one of the main statistical dangers, for the International Tin Study Group are primarily concerned with tinplate (in its strict technical sense) and, to a lesser extent, terneplate. They publish no figures for blackplate—nor indeed is there any reason why they should.

For a study of tinplate consumption, however, statistics of tinplate, blackplate and terneplate need to be considered together, since, apart from the final coating process, their manufacture is identical and, in some fields, at any rate, their uses are interchangeable.

The British Iron and Steel Federation publish figures of production and deliveries for "Tin, Terne and Blackplate" in their *Monthly Statistical Bulletin*. Trade and Navigation Accounts show exports of "Tinplate" separately. In these Accounts terneplate is grouped with terne-sheets and decorated printed and lacquered tinplate, blackplate and terneplate. Blackplate is included with black sheets.

The American Iron and Steel Institute publish statistics of shipments of "Blackplate, ordinary", "Blackplate, chemically treated", "Tin and terne plate, hot dipped", and "Tin and terne plate, electrolytic".

The United Nations publication, *Quarterly Bulletin of Steel Statistics for Europe*, includes the following classifications among the "selected end products", whose production is listed separately:

39 Tinplate and terneplate.
40 Blackplate for use as such.

Of the raw materials in the manufacture of tinplate in the U.K. deliveries by steelmakers of tinplate bars and slabs are given in the *Monthly Statistical Bulletin of the British Iron and Steel Federation*. The consumption of tin in tinplate manufacture in the U.K. is given in the *Bulletin of the British Bureau of Non-Ferrous Metal Statistics*. A total figure for the world consumption of tin in tinplate manufacture is published in the *Monthly Statistical Bulletin of the International Tin Study Group*.

Unhappily the end-uses of tinplate are not nearly as well-documented statistically as other forms of steel. During the period between May, 1950 and February, 1952, when the distribution of steel (other than tinplate and sheets) was free from control, the British Iron and Steel Federation published statistics of deliveries by many types of steel and by consuming industries, but such statistics for tinplate, for reasons connected with the administration of the distribution scheme, were not published. Statistics, therefore, which I show in Table 7 below have been compiled from a variety of sources.

(c) *Tinplate Production*

(i) *History*

Although Andrew Yarranton, who manufactured tinplate in 1667, is generally regarded as the father of the British tinplate industry, there are, in fact, references to tinned plate being manufactured by John Tilte, of a Bromsgrove family, in 1623.

Yarranton's efforts were, however, short-lived, and the birth of the industry dates from 1720, when the Hanbury family began to tin plates manufactured in their mill in Pontypool.

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Table 1, which I quote from Brooke's *Chronology of the Tinplate Works of Great Britain*, shows the development and expansion of the process of tinplate manufacture in South Wales during the 19th century.

This table, in which the production statistics are in basis boxes (area) and the export statistics are in hundredweights, illustrates the difficulty of dual units of measurement which besets any precise statistical investigation into the early history of the industry, and which, as I have indicated, is, to some extent, still felt to-day.

TABLE 1

U.K. Tinplate Production, Exports and Home Consumption (1834–1950)

	U.K. Production '000 *boxes*	*Estimated U.K. Consumption* '000 *boxes*	*Exports* '000 *cwts.*
1834	180	—	—
1848	335	—	—
1851	749	—	—
1860	1,550	250	1,201
1870	2,700	500	2,002
1880	6,350	1,250	4,354
1890	11,280	2,000	8,374
1900	10,000	2,610	5,735
1910	15,546	4,803	9,660
1920	12,215	4,429	7,060
1930	16,288	5,772	9,869
1940	20,545	11,180	7,616
1950	16,472	10,577	4,958

TABLE 2

Tinplate Production in the U.K., U.S. and World 1900–1951

	U.K. ('000 *long tons*)	*U.S.* ('000 *long tons*)	*World* ('000 *long tons*)
1900	500·0	302·7	900
1910	777·3	722·8	1,640
1920	608·5	1,410·7	2,160
1930	814·4	1,680·9	3,000
1935	708·3	1,783·0	3,373
1936	814·8	2,230·2	3,953
1937	957·8	2,562·5	4,625
1938	610·0	1,544·2	3,233
1939	919·4	2,399·3	3,945
1940	976·8	2,445·2	3,970
1941	719·7	3,133·4	4,275
1942	678·2	2,434·9	3,350
1943	532·1	1,928·5	2,430
1944	520·8	2,364·3	2,800
1945	511·8	2,524·5	2,785
1946	584·0	2,419·3	3,058
1947	663·6	3,354·6	4,145
1948	735·4	3,579·0	4,486
1949	750·7	3,395·1	4,561
1950	763·6	4,243·0	5,753
1951	756·9	4,031·9	5,640

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One significant point which Table 1 demonstrates is the extent to which the industry was built up on the export trade. In particular, it supplied practically the whole of the United States market until the McKinley Tariff came into operation in 1891. The next five years saw the virtual birth and rapid early growth of the United States tinplate industry. Total U.K. exports decreased from 448,732 tons in 1891 to 279,430 tons in 1896, and the United States annual production of tinplate and terneplate rose from about 2,000 tons to 137,000 tons in the same period.

The U.K. statistics include terneplate and blackplate throughout. The U.S. statistics refer to tinplate and terneplate ("short ternes"). The figures for 1900 and 1910 include a small element (not likely to be more than 3 per cent.) of "long ternes" which are now normally classified as "sheets". The statistics of world production relate in the main to tinplate only, but they are the sum of different national figures, some of which include an element of blackplate.

Both United Kingdom and United States production continued to increase until shortly before the first world war, and the United States production first exceeded United Kingdom production in 1912. At that time the two countries together accounted for 91·9 per cent. of world production.

During the inter-war period the United States expanded her industry, and converted it entirely from the hot-rolling process involving very heavy manual labour to the highly-mechanized cold reduction process in continuous strip mills. It was not until 1937 that the first (until 1951, the only one) of such mills at Ebbw Vale was erected in the U.K., and in 1951 over 70 per cent. of British tinplate was still being produced by methods not substantially different from those used 150 years ago.

I should like to draw your attention to the figures for the year 1938 in Table 2. It will be seen that both in the United States and in the United Kingdom production was very high in 1937 and very low in 1938. It is quite certain that the 1938 figure of production does not represent the level of consumption, since considerable stocks were undoubtedly held over from 1937. It is unfortunate that (being the last complete year before the war) the 1938 production figure is frequently taken as being typical of the immediate pre-war years, and many comparisons of pre-war and post-war production have been based on this fallacy. With the exception of 1926 (the year of the General Strike) the production in the U.K. in 1938 was the lowest since 1921, and was 26 per cent. below the average level of 1935–7.

During the 1939–1945 war shortage of tin and competing demands for steel, and the fact that tinplate manufacture was not a reserved occupation, reduced U.K. production from 919,400 tons in 1939 to 511,800 tons in 1945. Since 1945 production has increased from this nadir, but owing to shortage of skilled labour and lack of modern manufacturing facilities, production in 1951 was lower than that achieved by the industry 40 years ago.

Graph 1 illustrates not only the steady growth of U.S.A. production during the last half-century while production in the U.K. has shown little significant variation, but also the substantial increase in U.S. production since 1945 while U.K. production was still below the level of the inter-war years.

TABLE 3

U.K. Tinplate (including Blackplate and Terneplate) Production as a Proportion of Crude Steel Output

(*Annual Averages*—'000 *Tons*)

	Tinplate Production	*Crude Steel Production*	%
1901–05	583·5	5,137	11·4
1906–10	712·7	6,107	11·7
1911–15	764·6	7,461	10·2
1916–20	522·4	9,042	5·8
1921–25	662·6	6,730	9·8
1926–30	766·3	7,635	10·0
1931–35	737·2	7,239	10·2
1936–40	855·7	12,273	7·0
1941–45	592·5	12,450	4·8
1946–50	699·5	14,482	4·8

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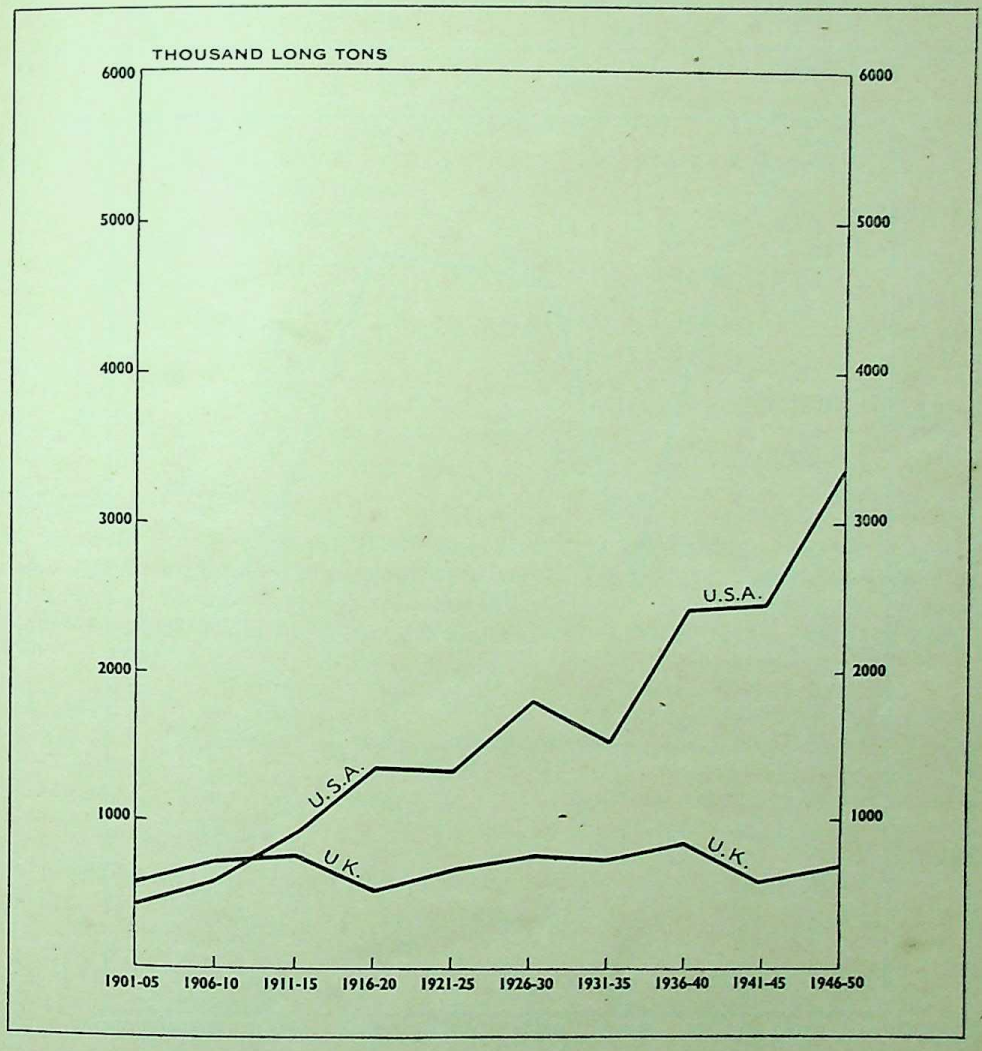
Table 3 and Graph 2 develop this point as far as U.K. production is concerned, and show the fall in the proportion of the nation's steel resources which have been devoted to tinplate manufacture since 1901.

During 1951 a new continuous strip mill for tinplate manufacture was opened at Trostre. This mill, fed with hot rolled strip from Margam, is still at the running-in stage, but should eventually be capable of an annual output of 400,000 tons. Its construction may be regarded as

GRAPH 1.—Tinplate production—U.S.A. and U.K., 1901–1950.
All figures of production are 5-yearly averages.



Note.—U.K. figures include tinplate, terneplate, and blackplate.
U.S.A. figures include tinplate and terneplate only.

the first stage in the post-war development and modernization of the tinplate industry. A second similar mill approved as part of this country's steel programme in the White Paper of 1946 (Cmd. 6811) has not yet been begun.

During the late thirties and since the 1939–45 war tinplate production has been begun or expanded in many countries. In particular, since the war modern plants have started operating, or are at present being installed in Canada, South Africa, France, Germany, Belgium, Netherlands, Argentine, Brazil and Japan.

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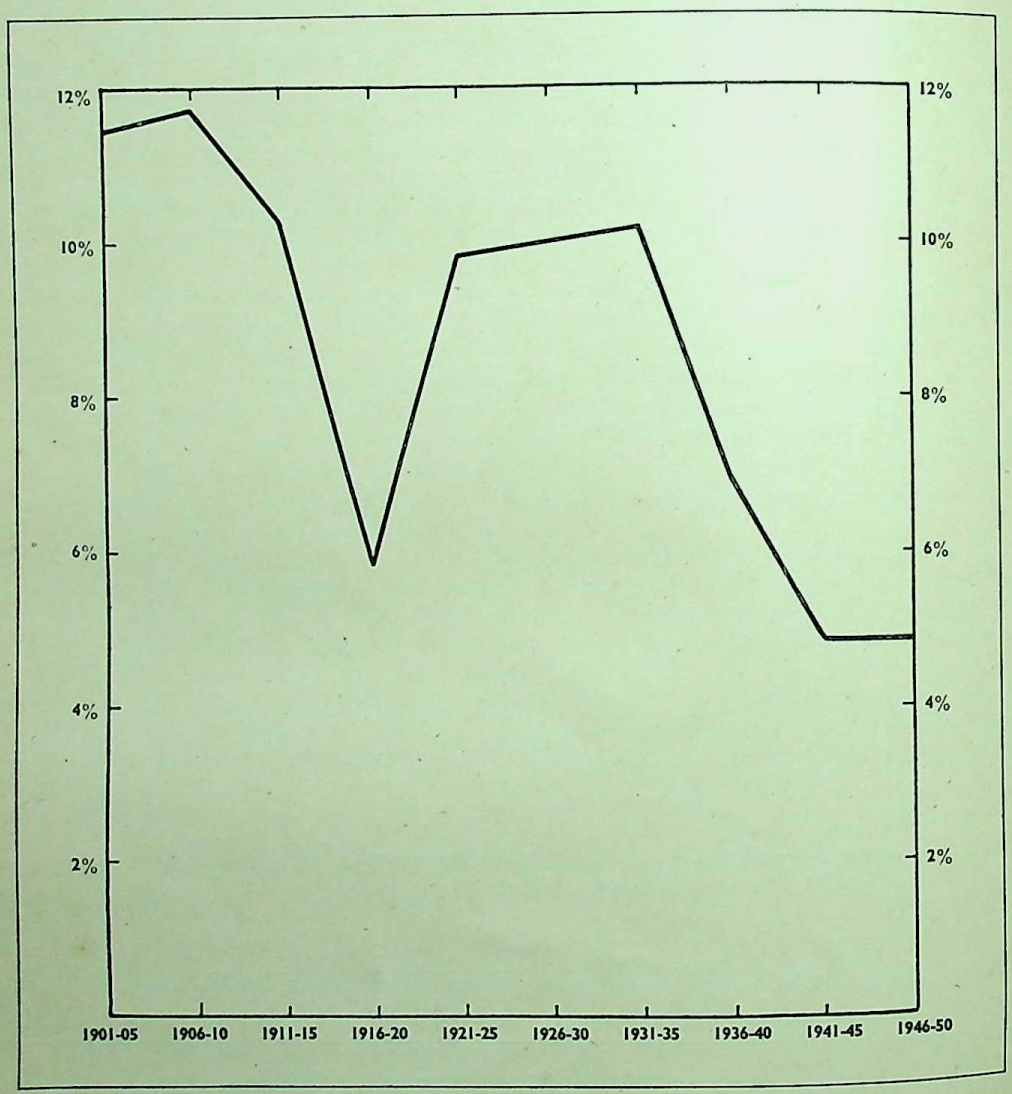
During the war shortage of tin caused the United States tinplate producers to develop the process of depositing tin electrolytically instead of by dipping in a tin bath. This process produces a more even layer of tin, and less tin is required to give the tinplate the same chemical and physical properties. In 1942 3 per cent. of United States tinplate was coated by this method; by 1951 it had risen to 63·8 per cent. It, however, appears that for many important uses hot dipped plate is still necessary.

GRAPH 2.—U.K. tinplate production: Proportion of tinplate output to total output of crude steel, 1901–1950.
All percentages are 5-yearly averages.



In the U.K. an electrolytic tinning line has been installed at Ebbw Vale since 1948, and another should be installed at Trostre this year. In 1951 9·5 per cent. of U.K. production was tinned electrolytically.

(ii) *Production and Consumption*

Table 4 analyses the production and deliveries of tinplate, blackplate and terneplate in the United Kingdom in 1951.

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TABLE 4

U.K. Tinplate (including Blackplate and Terneplate) Production and Deliveries, 1951

	Tons
(a) *Production by Method of Manufacture*	
Cold Reduced	
Ebbw Vale	202,913
Trostre	5,322
Hand Mills	533,764
	741,999
(b) *Deliveries by Type of Product*	
Tinplate	629,269
Blackplate	87,095
Terneplate	2,988
	719,352
(c) *Deliveries*	
Export	237,035
Home	482,317
	719,352

(iii) *Exports*

The figure for exports in trade and navigation accounts for 1951 for tinplate is 239,663 tons. An analysis of the exports by 19 countries is shown in Trade and Navigation Accounts, and a more detailed analysis by 47 countries is published in the *Statistical Bulletin of the International Tin Study Group*, and in *The Tin-Printer and Box Maker*. The analysis for 1951 is as follows:

TABLE 5

Exports of Tinplate by Country of Destination, 1951

Country	*Tons*
Belgium	104
Denmark	6,919
Eire	1,159
Finland	567
France	37
Greece	258
Holland	5,831
Italy	54
Norway	1,975
Portugal	440
Spain	178
Sweden	1,237
Switzerland	94
U.S.S.R.	1,811
Canada	337
U.S.A.	224
British West Indies	2,322

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TABLE 5 (continued)

Country	*Tons*
Argentine	27,853
Brazil	5,318
Ecuador	4
Paraguay	1,147
Uruguay	4,237
India	13,248
Pakistan	10,925
Malaya	12,124
Burma	4,411
Siam	4,418
Ceylon	1,962
China	767
Dutch East Indies	983
Hong Kong	3,509
Philippines	3,082
Anglo-Egyptian Sudan	3,464
Egypt	3,906
Iraq	891
Iran	5,874
Palestine	302
Syria and Lebanon	1,025
Turkey	2,831
British East Africa	3,871
British West Africa	2,846
Mozambique	1,162
Union of South Africa	12,405
Australia	64,622
New Zealand	15,814
Other countries	3,475
Total	239,663

The provision by the Commonwealth of canned food for this country, and the export of canned food to other markets, rely to a considerable extent on our exports of tinplate to them. In the case of certain foreign countries we are also committed to export tinplate to "clothe" food which we import from them. The Parliamentary Secretary to the Ministry of Supply (*Hansard*, February 27th, 1951, col. 1958) estimated the total annual figure for the "clothing" of food imports from the Commonwealth and foreign countries at about 55,000 tons.

With certain other countries the supply of tinplate is part of a bilateral trade agreement. In the case of a large number of non-European countries the export of tinplate is for the fabrication of containers for the local distribution of oil by the British oil companies. The President of the Board of Trade (*Hansard*, March 3rd, 1952, col. 17, written answers) has estimated this element at 60,000 tons.

The following table shows the relation between U.K. tinplate exports and the estimated tinplate content of U.K. canned food imports (i.e., the tinplate used in the manufacture of the cans) from the major food-canning countries outside the Commonwealth to which we exported tinplate for the year 1951.

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TABLE 6

	U.K. Tinplate Exports, 1951	*Estimated Tinplate Content of U.K. Canned Food Imports, 1951*
	Tons	*Tons*
Denmark	6,919	12,264
Holland	5,831	20,226
Norway	1,975	724
Sweden	1,237	675
U.S.S.R.	1,811	1,005
Argentine	27,853	6,457
Brazil	5,318	185
Paraguay	1,147	645
Uruguay	4,237	1,234

In the case of Denmark and Holland the imports of canned food were abnormally high in 1951 compared with previous years. The figures for the Argentine show that less than 25 per cent. of the tinplate which we exported to them returned to the U.K. as cans for canned meat. Argentinian canned meat imports were, in fact, lower in 1951 than had been planned but, in any case, the Argentine Agreement provided for their retaining for their own purposes the major part of U.K. exports of tinplate to them.

(iv) *Home Consumption*

The following table is an estimate of consumption of tinplate in the United Kingdom in 1951:

TABLE 7

Estimated Analyses of U.K. Tinplate (including Blackplate and Terneplate) Consumption in 1951

	'000 *tons*	'000 *tons*
Containers for processed food	136	
Containers and closures for non-processed food	134	
Total containers and closures for food	—	270
Containers and closures to pack products other than food		100
Containers exported as flattened cans or "made-up" containers		12
Total containers and closures		382
Hollow-ware		45
Other uses (toys, motor, radio, electrical industries, etc.)		55
		482

These estimates are based on the assumption that there was no change in tinplate stocks during 1951, i.e., that all deliveries of tinplate passed into consumption. This assumption is reasonable, as all tinplate consumers have been operating on minimum working stocks since 1945. The item "hollow-ware" consists *inter alia* of household hardware (including items of kitchen equipment) and containers made of blackplate which are galvanized or otherwise coated after manufacture.

3. SUNDRY MATERIALS USED IN THE TIN BOX INDUSTRY

(a) *Tin*

Tin is used in the tin box industry in the main ways:

(i) As a coating on tinplate.
(ii) As a constituent of solder

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Of the 23,892 tons of tin consumed in the U.K. in 1951, 9,417 tons were used in the manufacture of tinplate and 3,277 tons in the manufacture of solder. I estimate that of this latter amount, about 650 tons were used in solder in the tin box industry.

I should like, at this stage, to clarify a common misconception on the source of the tin which is consumed in the U.K.

It is too widely believed that the U.K. relies on Malayan tin for consumption in this country. In general (and I refer to the abnormal conditions in 1951 below) the U.K. imports tin concentrates from countries other than Malaya for smelting in the U.K. smelters. These smelters produce sufficient tin metal for the whole of the U.K. domestic consumption and, in addition, provide an exportable surplus. In the immediate pre-war years and again in 1950 and 1951 the U.K. did, in fact, import tin metal from Malaya, but (except in the year 1951) an equivalent amount of tin metal was exported in addition to the exportable surplus from the smelters.

As the word "ore" has a special significance in the tin trade, the word "concentrate" is used in international tin statistics to describe the raw material of the smelting operation.

The following table shows the imports of "tin in concentrates" (i.e., the tin content of the concentrates) into the U.K. in 1950 and 1951:

TABLE 8

Country of Origin	*Tons*	
	1950	1951
Nigeria	8,424	8,241
Other Br. Africa	197	12
Bolivia	17,050	18,086
Other S. America	489	97
Portugal	702	508
Other countries	493	406
Total	27,355	27,350

No tin concentrates were imported from Malaya in either year.

From 1945 to 1949 (inclusive) no appreciable quantity of tin metal was imported into the U.K., but after the opening of the London Metal Market in November, 1949, tin metal has been imported from Malaya. 7,318 tons were exported from Malaya to the U.K. in 1950, and (after the temporary cessation of U.S. purchases) the figure rose to 15,248 tons in 1951. Exports of tin metal from the U.K. were 15,460 tons in 1950 and 4,922 tons in 1951, thus making the U.K. for the first time in many years a net importer of tin metal in 1951.

Although the U.K. imported tin metal before the war (imports in 1935–8 averaged 17,500 tons per annum), the U.K. was always a *net* exporter of tin metal during those years. 1951 was, therefore, an abnormal year by post-war or immediate pre-war standards, and we may hope and expect that in the future the 1950 pattern of trade will be more normal, i.e., for the whole of the U.K. home consumption to be derived from the smelting of imported concentrates, and for the U.K. to undertake a net export trade in tin metal smelted in Britain.

(b) *Lead*

Lead is chiefly used in solder in the tin box industry, and the 1951 consumption of lead in solder in the industry is estimated as being about 850 tons.

(c) *Printing Inks, Varnishes and Lacquers*

The industry uses lacquers primarily as a protective coating to stop chemical action between the inside of the can and the contents. It uses printing ink, varnishes and lacquers to decorate the outside of its containers. Its total consumption is estimated to be in the neighbourhood of 2,000 tons per annum.

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4. TIN BOX INDUSTRY

(a) *General Structure*

The scope of the industry for the purpose of this paper is the manufacture of containers from tinplate of a capacity not exceeding 5 gallons. With this industry is allied the manufacture of tinplate closures for glass bottles, and although it is with the tin box industry that I am primarily concerned, I shall make certain references to the tinplate closures industry.

The tin-box industry is made up of some 100 firms, of which about 70 are firms manufacturing containers for sale, and about 30 are manufacturers of other products who *inter alia* manufacture their own metal containers. In all it covers about 40,000 employees, and the capital invested in the industry is of the order of £25 millions.

(b) *History*

The industry is divided into two fairly distinct parts which can best be considered separately:

(1) the manufacture of "Open Top" cans, i.e., cans to contain processed food, and
(2) the manufacture of "General Line" containers, i.e., containers for products other than processed food.

The industry in this country dates back to the 17th century. In 1670 Charles II granted a charter to the Tinplate Workers (i.e., workers using tinplate), who in the following year were admitted a Free Company of the City. The tinplate on which they worked was imported from Saxony.

The traditional business of the industry has been the manufacture of General Line containers. The old tinsmith many decades ago using primitive tools and a soldering-iron made tins for paint, tobacco, confectionery, cocoa and oil; tins for these same commodities constitute a substantial proportion of the production of the tinsmith's modern counterpart—manufactured with highly mechanized machinery on automatic lines.

The major development, however, in the industry in the last 30 or 40 years has been the growth of Open Top can manufacture to provide cans for the canning industries which have developed in almost every country in the world.

The canning of milk had been well established in the United Kingdom by the 1914–18 war, but it was not until about 1930 that the major developments in fruit and vegetable canning took place. Production of Open Top cans in 1924 was about 150 millions. This had risen in 1935 to 600 millions, to 1,000 millions in 1939 and to-day stands at about 1,600 millions.

(c) *Statistical Sources*

Production of the tin-box industry is classified as Hollow-ware (2 metal boxes and containers) minimum list heading 94, Ministry of Labour code GWH of the Standard Industrial Classifications and will be included in the Final Report on the Census of Production for the Hardware, Hollow-ware, Metallic Furniture and Sheet Metal Trades. The report on the 1948 Census has not yet been published but Table 9 shows some provisional figures of sales of boxes and containers, metallic closures and decorated tinned plates.

I must warn you, however, of pitfalls in the interpretation of the Census figures—pitfalls, which will, I fear, reappear to a lesser extent in the report of the 1951 Census.

Firstly the figures do not, in general, include the output of General Line or Open Top containers by many manufacturers of canned foods, syrup, polish, biscuits, etc., who also manufacture the containers in which they pack their products. The production in 1948 appropriate to these omissions was probably of the order of 80,000 tons in weight, and £5,500,000 in value.

The second pitfall arises from the fact that in order to achieve the benefits of mass production the leading manufacturer in the industry manufactures certain components for all his cans in one "establishment", separated geographically from the various "establishments" in which the complete cans are manufactured. At the time of the 1948 Census the Board of Trade ruled that these components should be returned under the general heading "Open Top hermetically sealed" on the schedule of the "establishment" in which they were manufactured, and that the complete cans should be returned under the same heading on the schedule of the establishment in which they were produced. Each component has, therefore, been included twice in the consolidated results. This duplication is of the order of 35,000 tons in weight, and £2,500,000 in value.

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TABLE 9

Hardware, Hollow-ware, Metal Furniture and Sheet Metal Trades

Sales in 1948 (including sales by establishments classified to other trades)

		Th. tons	£,000
Boxes and containers from tinplate, blackplate or terneplate, not elsewhere specified (including covers and components therefore):			
Open Top hermetically sealed		124·1	10,226
For biscuits		9·3	776
Other descriptions		99·7	11,046
		—	1,323
Boxes and containers of aluminium		3·9	1,392
		—	730
Composite containers partly of metal*		4·2	511
		—	51

	Million	*Th. tons*	£'000
Metallic closures for bottles, jars, cans and similar containers (excluding crown corks, covers for metal and composite containers and cork stoppers partially manufactured from metal):			
Aluminium capsules	1,058	0.9	817
	203	—	220
Lead capsules	182	13·3	467
Black plate or tinplate closures	1,057	9·1	1,724
Other metallic closures	200	1·0	509
	23	—	51
	—	0·4	61
Crown corks	4,576	14·1	2,205
Tinned plates, sheets and strips, decorated, printed etc. sold in the flat or partially shaped for boxes and other containers.		35·3	1,834

* Sales in Hardware, Hollow-ware Trade only.

A similar anomaly occurs under the heading "Tinned Plates, etc.", where almost the entire output figure of 35,300 tons consists of lacquered tinplate which is, in fact, a raw material of the output shown as "Open Top, hermetically sealed".

In view of these anomalies and the margin of error involved in estimating the size of the first of them and the lack of statistical information on non-container uses of tinplate, I have not attempted to build up a statistical analysis of the consumption of tinplate in 1946. I would refer you to Tables 7 and 10, where I make certain estimates of this nature for 1951.

(d) *Output of the Tin Box Industry.*

As the products of the industry vary in size from a 5-gallon oil drum to a sample ointment tin barely larger than a shilling, figures of *numbers* of containers have no significance whatever.

For overall statistics of output the most common measures are the weight (tons) or area (basis boxes) of the tinplate used in the fabrication of the containers. Where figures of weight are used it must be remembered that this does not represent the actual weight of the output of containers, since fabricating losses vary from 5 per cent. for, say, the familiar standard biscuit tin to 28 per cent. for a large tin of the type used for boot-polish, where the process of stamping circles out of rectangular sheets gives rise to considerable unavoidable fabricating losses.

Table 10 is an estimated analysis of the tinplate consumption in the manufacture of processed food cans in 1951.

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TABLE 10

Estimated Analysis of Tinplate Consumption in the Manufacture of Processed Food Cans in 1951

	'000 *tons*
Fruit	16
Vegetables	70
Fish	6
Milk	20
Soup	15
Other	10
	136

The Census of Production reports of the tin-box producing and consuming industries are the only official source of statistics for the industry, and although I have referred to certain pitfalls in their interpretation, I want to emphasize the value of these Census reports in an industry which would otherwise be ill-provided with statistical information.

Table 11 is made up of extracts from those reports of the 1948 Census as have already been published on the purchases of tin-boxes and metal containers.

TABLE 11

Purchases of Tin Boxes and Metal Containers as Shown in the 1948 *Census of Production* (*Table* 13: *Larger Establishments*)

Trade	*Classification*	£'000	'000 *cwt.*
Food			
Cocoa, Chocolate and sugar confectionery*	Tin Boxes and containers	432	89
		208	—
Biscuits*	Tin containers	576	136·9
		419	—
Preserved fruit and vegetables	Tin containers	1,989	578
		3,151	3,371 ('000 gross)
Tea-blending and coffee roasting	Tin containers	141	30
		92	—
Sugar and glucose*	Tin containers	506	142·1
		107	—
Non-Food			
Polishes	Metal boxes and containers	1,316	203
		299	—
Tobacco	Tin containers	New 1,080	174
		Used 5	—
Ink	Metal containers	32	6
		85	—
Paint and varnish	Tin containers	3,182	—

* Includes those items shown as being transferred from branch establishments under the same ownership.

In addition the following are the provisional figures for the Milk Products trade:

Milk products	Metal containers	486	142·0
		135	—

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This table is published with the object of putting on record such information as is available. Although adjustments have been made to include, in some cases, items transferred from *branch* establishments under the same ownership, the practice is not universal, and its universal application would help to remove a source of misunderstanding referred to earlier. It is, however, the production of containers in the *same* establishment in which they are filled which remains concealed in many trades. In one trade, however (the Cocoa, Chocolate and Sugar Confectionery trade) ancillary output in larger establishments is shown as follows:

Tin Boxes and Containers . . . . . 90 thousand cwts.

Within individual firms in the tin-box industry the practice of coding sales of containers according to the product to be packed in them is a fruitful source of information on the consumption of tin boxes by trades. A leading manufacturer analyses his sales in this way, and this information may form a basis for the kind of research into the use of tinplate which I mention in Section 6.

Exports

Tin-boxes are exported in two forms:

(*a*) (i) As empty containers, e.g., highly-decorated boxes to be eventually sold as such or as the containers for other products (e.g., toffees).

(ii) Food cans, which are partially-formed in the U.K., flattened for convenience of transport and re-formed overseas before being packed with canned food.

(*b*) As containers for goods which are exported from the U.K.

Statistics of (*a*) (i) and (ii) are included with many other items under Class III Group C in Trade and Navigation Accounts as—

"Hollow-ware of tinned plate or tinned (not cast)—boxes and containers for trade and industrial purposes, empty and parts, thereof".

The President of the Board of Trade (*Hansard*, March 3rd, 1952, col. 17, written answers) estimated the figure for (*a*) (ii) for 1951 at 7,000 tons, but there is reason to suppose this estimate may be a low one.

The following table is an estimate of the tinplate used in the manufacture of tin boxes which were exported, either empty or filled, in 1951:

TABLE 12

	Tons
Empty containers, not flattened, sold as such . .	5,000
Flattened cans	7,000
Filled containers	
(a) Processed food	6,000
(b) Non-processed food	24,000
(c) Non-food	25,000
	67,000

The item "Empty containers, not flattened, sold as such" is mainly composed of cans for Eire or highly-decorated containers for dollar markets.

The major item in "Filled Containers, Processed Food" is canned herrings. Biscuits and confectionery are the chief items under "Filled Containers, Non-processed Food". In the "Non-Food" group the main "non-food" items are tobacco and cigarettes.

From time to time analyses have been prepared of the conversion value of a material in relation to the value of the end-product in which it is exported, and in some industries allocations of raw materials have, in fact, been made on this basis.

The following table shows the conversion factors (by value) between the tinplate content of filled containers and their f.o.b. value. These factors represent typical ratios for individual packs.

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TABLE 13

Canned herring in tomato (14-oz.)	7
Confectionery (1-lb. toffee)	13
Coffee (½-lb.)	15
Cigarettes (50, airtight pack)	19
Biscuits (decorated containers)	21
Talcum powder	25
Paint (1-gallon)	45

The subject of the conversion factors of raw materials used in fabricating exports requires considerably more study than has been given to it to date, and this is a field in which further research would be profitable.

(e) *Prices.*

The two main factors affecting the price of tinplate are the prices of (*a*) tin and (*b*) steel. The price of tin is related to the controlled price of tinplate as follows: A difference of £10 per ton in the price of tin is responsible for a difference of 1*d.* per basis box in the controlled price of tinplate. The price of tinplate in the U.K. is altered at the beginning of each calendar quarter to reflect variations in the price of tin. The price of tinplate in each calendar quarter is based on the average cash price for standard tin on the London Metal Exchange in the three-monthly period ending one month before the beginning of that calendar quarter. This average price of tin is published in the *London Gazette* as a difference from the standard tin reference price of £600 per ton. Thus the price of tinplate in the quarter July-August-September is based on the price of tin in the three months March-April-May, and this latter price is published in the *London Gazette* during the third week in June.

The published controlled price of tinplate (the latest price is indicated in the Iron and Steel Prices Order 1952, S.I. 1952, No. 361) is based on a tin price of £600 per ton (the standard tin reference price). Quotations in the press, however, normally refer to the current ruling price and include the current variation in the tin element.

The following table shows the changes in the price of tinplate since 1945:

TABLE 14

Price of Tinplate per basis box I.C.

	s.	*d.*
Average 1939	20	6
1941–1945	29	9
January 1st, 1946	32	6
August 14th, 1946	34	3
September 26th, 1946	34	11·56
March 29th, 1947	35	4·91
October 1st, 1947	36	3½
December 17th, 1947	36	11½
January 28th, 1948	37	0½
June 1st, 1948	37	5½
April 1st, 1949	41	6
September 26th, 1949	43	0
November 15th, 1949	42	10
December 16th, 1949	41	9
October 1st, 1950	42	5

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TABLE 14—*continued*

	s.	*d.*
January 1st, 1951	44	4
February 21st, 1951	45	2½
April 1st, 1951	48	3½
July 1st, 1951	47	9½
August 13th, 1951	54	8½
October 1st, 1951	52	1½
January 1st, 1952	52	8½
February 27th, 1952	57	2½
April 1st, 1952	57	1½

Prices before and after April 1st, 1949, are not directly comparable. Prices from April 1st, 1949, are quoted "Unassorted". Before that date, "Unassorted" plates were sold at 3*d.* per box less than the quoted price.

Of the increase in the price of tinplate since 1945, 6*s.* 6*d.* can be directly attributed to an increase in the price of the tin element on the above basis of calculation.

The continuing increase in the price of tinplate over the last six years has been the major reason for the rise in price of metal containers. The following table shows the price of a standard A2 (20·4 fluid ounces) can in the last 12 years.

TABLE 15

Selling Price of an A.2 Can, Plain, Loose, Unpacked, Ex Works

	Per 1,000 *s.*	*d.*
January 1st, 1940	90	3
January 1st, 1944	113	8½
March 1st, 1946	115	2
July 15th, 1946	118	11
November 1st, 1947	128	1
June 1st, 1948	131	3
May 1st, 1949	144	5
November 1st, 1949	150	11
February 1st, 1950	145	7
January 1st, 1951	158	4
May 1st, 1951	174	2
October 1st, 1951	178	6
April 1st, 1952	193	9

Notwithstanding the substantial rise in prices of metal containers since 1939, in general the ratio "cost of the container"/"retail price of packed product" is less now than before the war. The following table compares the 1939 and 1951 value of this ratio for a typical range of products packed in tinplate containers.

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TABLE 16

Cost of Container as a Percentage of Retail Selling Price

	1939 (*December*)	1951 (*December*)
Garden peas (1-lb. can)	21·2	13·3
Strawberries (1-lb. can)	10·8	6·8
Herring in tomato (14-oz.)	16·9	18·0
Evaporated milk (16-oz.)	10·2	11·1
Cocoa-based beverage	12·6	11·9
Paint (1 gallon)	3·7	2·8
Talcum powder	29·7	19·0

(f) *Standardization.*

The industry has for many years adopted a policy of standardization of containers, and although in several cases these standard sizes have the force of law behind them at present, there is little doubt that in the canned food trade, at any rate, there would be few departures from the principles of standard sizes were the legal restrictions removed, though a larger number of standard sizes would doubtless be manufactured. Thus at present fruit may only be canned in one of five standard size cans, and vegetables (other than beans in tomato sauce) are restricted to six sizes.

In the General Line side of the industry the trend has been to standardize on the diameters of containers so that standard components (ends, rings, lids, etc.) can be manufactured.

A leading manufacturer who, before the war, manufactured round "built-up" containers on over 100 different diameters between 2 in. and 9 in. and with very little concentration of production on any particular diameters now concentrates 80 per cent. of his production on 18 diameters in this range.

(g) *Scrap Cans.*

Considerable interest has been aroused recently in tin cans as a source of tin or steel scrap. Tinplate scrap may be derived in two ways—either as manufacturing scrap from the tin and can manufacturing industry or as scrap cans, hollow-ware, etc., through municipal refuse dumps. Based on 1951 figures the potential extent of this scrap can be calculated as follows:

TABLE 17

	'000 *Tons*
Home deliveries of tinplate/blackplate/terneplate	482
Excess of cans imported over cans exported	30
	512
Non-container tinplate, not recoverable	35
	477
This amount should be recoverable as follows:	
As manufacturing scrap	76
Through municipal refuse dumps	401

The above estimates have, in fact, been challenged as being on the high side, but I believe them to be sound ones.

The manufacturing scrap is, in fact, all collected and de-tinned and full use is made of both the tin and steel elements.

Of the scrap recoverable through refuse dumps, there are only facilities in the U.K. for de-tinning, at most, 5 per cent. of the potential supply, and therefore about 4,000 tons of potential secondary tin are lost annually in this way. After de-tinning the steel scrap can be sent to the

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steel furnaces. Scrap from which the tin coating has not been removed is not suitable for steel furnaces and must be sent to the blast furnaces. During 1951 it is estimated that 130,000 tons of scrap were sorted by municipal authorities in England, Scotland and Wales and sent either for de-tinning or to blast furnaces. A steel scrap collection of little over 30 per cent. of potential cannot be regarded as satisfactory in these times of steel scrap scarcity.

5. The Canning Industry

(a) *History*

In 1809 Nicholas Appert, a Parisian confectioner, was awarded a prize of 12,000 francs by the French Government for his discovery of a method of preserving certain foods in special glass bottles, which were subsequently immersed in boiling water for varying periods. He published a book on his methods in 1810, the same year in which an Englishman, Peter Durand, patented a method of preserving foods in tin containers.

He never engaged in canning on a commercial scale, but in 1811 a process similar to Appert's was being developed in England by John Hall and Brian Donkin of the Dartford Iron Works. The latter must receive chief credit for developments about this time. By 1812 he had devised a process and set up a factory in Bermondsey to exploit it. In 1813 he had progressed sufficiently to submit tins of food for trial by military and naval authorities.

In 1815 English canned foods were used by a Russian explorer in the Arctic, and Sir Edward Parry used them in the same regions in 1824. The first canned foods, peas, tomatoes and sardines, appeared on the open market in 1830, and bacon and vegetables in tins were supplied to troops in the Crimea in 1855. It should be noted that all these containers were based on tinned iron—steel was too expensive at that time, and the first container made from tinned steel appeared about the beginning of this century.

It is of interest that actual cans used in the 1815 and 1824 Arctic expeditions have been opened in this century and the contents found to be in good condition. One can was 114 years old at the time of opening.

(b) *Statistical Sources in the Canning Industry*

The U.K. canning industry suffers from a dearth of statistical information. A move is now being made by the Fruit and Vegetable Canners' Association to remedy this position, since the industry compares very unfavourably in this respect with, for instance, the canning industries of the United States, Australia, South Africa and Malaya.

(c) *Production*

The Ministry of Food publish quarterly statistics of production of certain canned foods (mainly fruit and vegetables) based on returns from licensed canners. Table 18 shows these figures for 1948–51.

Table 18

Canned Fruit, Vegetables, Soups and Homogenized Baby Foods Production in the U.K. 1948/51

('000 *Tons Net*)

Variety	1948	1949	1950	1951 (*Provisional*)
Canned fruit				
Strawberries	(*a*)	(*a*)	(*a*)	5·1
Gooseberries	1·2	1·8	4·5	6·8
Other berries and currants	4·6	7·5	11·7	4·8
Cherries				5·6
Plums, damsons and greengages	36·6	44·7	35·2	36·3
Apples, sliced, purée and solid pack	9·1	12·7	16·0	8·4
Rhubarb	12·8	22·2	6·7	3·6
Other varieties	0·2	0·2	1·0	3·7
Total canned fruit	64·5	89·1	75·1	74·3

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TABLE 18—*continued*

Variety	1948	1949	1950	(*Provisional*) 1951
Canned vegetables				
Beans in tomato sauce	48·6	77·2	93·4	94·2
Tomatoes	0·2	3·1	0·6	0·1
Beetroot	(*b*)	(*b*)	(*b*)	1·0
Peas, processed	78·5	139·3	143·6	118·1
Peas, fresh	19·1	25·3	31·8	33·5
Macaroni and spaghetti in tomato sauce	28·0	21·7	21·6	20·5
Beans, stringless and runner	2·6	2·0	2·9	0·9
Celery				0·5
Spinach				0·3
Turnips, swedes and parsnips	(*b*)	(*b*)	(*b*)	0·5
Carrots	23·0	13·6	17·2	13·0
Other varieties (chiefly macedoine)	25·2	18·6	11·5	15·4
Total canned vegetables	225·2	300·8	322·6	298·0
Canned soups				
All varieties	110·5	71·2	60·3	70·3
Homogenized baby foods				
All varieties	6·9	7·2	5·1	7·9

(*a*) Strawberries included with "Other berries and currants and cherries" in 1948–50.
(*b*) Included in "Other varieties" in 1948–50.

The production of canned food since the war has been limited by the shortage of tinplate. Canning of food for the armed forces and the canning of milk and fish (the production of which I quote on Table 19) have a first priority on tinplate supplies. The increase in tinplate exports (which involve high quality tinplate suitable for canning) from 195,000 tons in 1949 to 248,000 tons in 1950 and 238,000 tons in 1951 without any commensurate increase in production has further diminished the tinplate available for canning fruit and vegetables in the last two years.

The statistics in Table 18 relate to the total contents of the filled can. The Ministry of Food lay down standards for minimum weights of *solid* content for different packs and different sizes of can in the Home Canned Fruit and Vegetables Order, 1950 (S.I. 675 of 1950), and the weights given in this Order can be used to make estimates of the total solid content of canned fruit and vegetable production.

There is one difficulty in obtaining accurate statistics on canned food by products. A number of Census reports (e.g., the Preserved Meat report, vol. 8, Trade F) classify canned and bottled products together, and in many cases the proportion of production which is bottled is of some substantial significance. A similar difficulty occurs in imports of fruit, but here, in general, the proportion of bottled produce is so small as to have little significance.

The following tables show statistics comparable to these in Table 18 for canned fish and canned milk. I am grateful to the Ministry of Food and Milk Marketing Board respectively for permission to publish these statistics.

TABLE 19

Production of Canned Fish
('000 *tons net*)

	1948	1949	1950	(*Provisional*) 1951
Herring	11	15	13	14
Sild and brisling	1	1	1	1
Pilchards, etc.	1	1	2	2
Total	13	17	16	17

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TABLE 20

Production of Canned Milk

('000 *tons net*)

	1948	1949	1590	1951 (*Provisional*)
Evaporated (F.C.U.)	49·3	58·2	71·2	46·0
Condensed (F.C.S.)	18·1	13·0	26·5	23·0
Skimmed (M.S.S.)	24·0	26·6	22·3	9·0
Total	91·4	97·8	120·0	78·0

Production of canned milk fluctuates considerably and is dependent on climatic factors. 1951 production was curtailed by bad weather affecting the growth of the grass in early spring.

In addition to the above main categories of canned foods, a number of other smaller packs are canned and the following is an estimate of the size of the pack in 1951:

TABLE 21

Estimates of Production in 1951 *of Minor Items of Canned Foods*

	'000 *Tons*
Meat puddings	5·0
Meat roll, etc.	9·0
Ready meals (stewed steak, M. and V., etc.)	6·0
Other meat products	3·0
Sweet puddings	5·0
Butter	0·4
Cheese	0·7
Margarine	10·0
Other	1·5
	40·6

The growth of the canning industry since 1924 can be well illustrated by the following table showing production in the years 1924, 1935, 1946 and 1951 (provisional). The 1924 and 1935 figures are Census of Production figures (except for soups and vegetables in 1924 and soups in 1935 where it has been necessary to make estimates). Statistics of fruit in 1924 and 1935 and of vegetables in 1935 refer to both canned and bottled products. 1946 and 1951 figures are based on Ministry of Food figures (except for milk, where the statistics are derived from the Milk Marketing Board).

TABLE 22

Production of Main Items of Canned Food

('000 *Tons*)

	1924	1935	1946	1951 (*Provisional*)
Fruit	5·6	23·3	21·7	74·3
Vegetables	1·0	60·6	238·2	298·0
Soups	1·0	10·0	81·9	70·3
Fish	7·6	8·6	6·0	17·0
Milk	38·3	148·7	84·7	78·0
Total	53·5	251·2	432·5	537·6

(d) *Imports and Exports of Canned Food.*

Tables 23 and 24 show the U.K. imports and exports of canned (and, where indicated, bottled) food for 1948–51.

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TABLE 23

U.K. Imports of Canned Food
('000 *Tons*)

	1948	1949	1950	1951
Fruit				
(Preserved with sugar—tinned or bottled)				
Apricots	2·5	3·1	1·9	1·4
Peaches	19·1	14·3	8·0	7·6
Pears	9·7	13·7	10·3	8·7
Pineapples	2·2	3·9	5·9	9·5
Fruit salad	0·6	—	0·2	1·5
Grapefruit	—	—	0·2	1·2
Oranges	(*a*)	—	2·6	10·7
Apples	(*a*)	5·3	1·4	0·6
Plums	(*a*)	0·3	6·1	2·8
Cherries (stoned)	(*a*)	0·1	0·5	0·3
Currants and berries	(*a*)	0·1	5·7	19·4
Other kinds	5·6	0·8	18·5	25·2
Total	39·7	41·6	61·3	88·9
Fruit				
(Preserved by chemicals, etc., tinned or bottled)	1·8	5·7	5·4	3·9
Vegetables				
(Preserved in airtight containers not preserved in vinegar)				
Beans in tomato sauce	2·0	22·4	15·0	35·8
Asparagus	0·2	0·4	0·2	0·5
Beans (unsweetened)	4·5	5·1	3·3	4·5
Peas	3·3	26·0	6·0	10·7
Tomato purée, paste or pulp	17·9	25·4	25·0	25·5
Other tomatoes	13·1	22·7	81·7	77·0
Other	14·0	15·3	13·2	6·1
Total	55·0	117·3	144·4	160·1
Soups	(*b*)	(*b*)	4·9	7·6
Milk				
Evaporated (F.C.U.)	7·8	13·4	11·6	30·7
Condensed (F.C.S.)	18·5	23·8	8·8	13·9
Skimmed (M.S.S.)	4·5	30·3	6·6	6·5
Total	30·8	67·5	27·0	51·1
Fish				
Brisling	0·9	2·4	3·0	1·1
Pilchards	0·1	6·9	2·2	0·2
Salmon	4·7	13·9	4·2	9·4
Sardines	7·8	7·3	15·1	5·8
Sild	(*a*)	3·5	3·2	—
Other kinds	11·5	11·5	2·5	2·4
Total	25·0	45·5	30·2	18·9

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TABLE 23—*continued*

	1948	1949	1950	1951
Meat				
Beef	48·0	74·2	67·1	72·2
Veal	9·4	2·7	1·7	5·9
Mutton	3·2	3·6	3·8	2·8
Pig products	9·6	12·9	34·6	94·8
Other meat	6·3	18·1	39·5	49·2
Poultry	—	—	0·4	1·6
Total	76·5	111·5	147·1	226·5

(*a*) Included in "other kinds".
(*b*) Not separately distinguished before 1950.
— Less than 50 tons.

TABLE 24

U.K. Exports of Canned Food
('000 *Tons*)

	1948	1949	1950	1951
Vegetables preserved in Airtight containers, not preserved in vinegar	4·4	3·8	4·6	6·4
Herrings	4·4	6·7	10·3	9·8
Other canned fish (including fish paste)	0·9	0·8	1·4	2·6
Milk, condensed, whole	3·8	5·2	8·7	9·5

Table 23 demonstrates the substantial increase in imports of canned fruit, vegetables and meat since 1948. To a large extent this was due to imports of these items from O.E.E.C. countries being placed on Open General Licence.

In interpreting these statistics it must also be remembered that in the case of meat a substantial element represents corned beef, canned in bulk (e.g., 14-lb. tins), and sold retail in smaller quantities.

The following table shows imports of the main items of canned food in 1924, 1935, 1946 and 1951:

TABLE 25

Imports of Main Items of Canned Food
(*Other than Fruit Juices*)
('000 *Tons*)

	1924	1935	1946	1951
Fruit	124·6	184·5	49·0	92·8
Vegetables	36·7	52·9	35·2	160·1
Meat	49·8	63·8	188·4	226·5
Fish	60·1	73·4	78·5	18·9
Milk	111·6	89·3	90·9	51·1
Soups	*	*	*	7·6
Total	382·8	463·9	442·0	557·0

* Not separately distinguished.

Statistics for fruit refer to "Fruit (Tinned and Bottled)". Statistics for vegetables for 1924 and 1935 refer to "Vegetables (Canned and Bottled)"; for 1946 and 1951 they refer to "Vegetables preserved in airtight containers, not preserved in vinegar".

Much of the pre-war imports of canned fruit came from the U.S.A., and currency considerations have stopped this trade. The relatively high figure for canned fish imports in 1946 reflects

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the canned salmon bought under the American and Canadian Loans. The fall in imports of canned milk is in line with the fall in consumption, to which I shall refer later.

(e) *Consumption of Canned Food*

Consumption of condensed milk, canned and bottled fruit, canned fish, meat and vegetables is shown in the *Monthly Digest of Statistics*. These figures are published as weekly averages in tons.

A little more detail is given in "Food Consumption Levels in the United Kingdom" (Cmd. 7842) which has been brought up-to-date (12 months to end of June, 1951) by tables in the *Ministry of Food Bulletin* No. 611 dated August 11th, 1951, and No. 632 dated January 5th, 1952. These figures are shown as "lbs. per head per annum".

These statistics need to be interpreted with some caution since, for example, canned tomatoes are included under "canned vegetables" in the *Monthly Digest*, but under "Fruit" in "Food consumption levels". Again, in "Food consumption levels" home produced canned processed peas and baked beans are included with dried peas and beans under "Pulses and Nuts", whereas imported canned processed peas and baked beans are shown under "Vegetables".

The following table attempts to compare *apparent* consumption (i.e., production plus imports less exports) of canned food in the U.K. in the years 1924, 1935, 1946 and 1951.

Owing to considerable fluctuations in distributors' stocks, particularly during the last two years, no direct comparison is possible between the statistics in the following table for the year 1951 and the corresponding figures in the *Monthly Digest of Statistics*.

Estimates for "other canned foods" have been made for the years 1946 and 1951. Estimates have also been made of U.K. production of canned (as opposed to "canned and bottled") meat.

TABLE 26

Apparent Consumption of Canned Foods (Other than Fruit Juices)
('000 *Tons*)

	1924	1935	1946	1951 (*Provis.*)	*lbs. per head* 1951
Fruit	124·2	207·3	70·7	167·1	7·5
Vegetables	36·7	113·5	264·2	451·7	20·2
Meat and Meat Products	42·0	53·8	213·4	249·5	11·1
Soup	1·0	10·0	81·9	77·9	3·5
Fish	54·3	75·1	81·3	23·5	1·0
Milk	143·4	221·7	171·2	119·6	5·3
Other	—	—	30·0	17·6	0·8
	401·6	681·4	912·7	1106·9	49·4

It may be of interest to note that in the U.S.A. canned food consumption was 39 lbs. per head in 1925 and 83 lbs. per head in 1951.

The consumption of canned fruit has been curtailed since 1939 owing to restrictions on dollar imports—this has been compensated to some extent by an increase in U.K. production.

Consumption of canned vegetables (particularly processed peas) has continued to increase very substantially since 1924. This is mainly due to increased U.K. production, but increased imports (particularly in the last two years) have been a significant factor.

Canned meat production in the U.K. has never been high, and increased imports both of corned beef and other canned meats are mainly responsible for the increase in consumption since before the war.

The consumption of large quantities of canned soup is a recently-acquired habit, although it has declined from its peak in 1948 as other foods have become more available.

The fall in imports of canned fish (particularly salmon from the U.S.A., Canada and Japan) is the major factor in the fall in consumption.

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The high consumption of canned milk before the war was due, to a large extent, to the fact that canned skimmed milk was cheaper than fresh milk. The increase in fresh milk consumption since the war (particularly in the lower-income groups) has been associated with a reduction in demand for skimmed, although the demand for better quality canned milk has been maintained.

6. Other Tin-box-using Industries

I have referred at some length to the canning industry, which is the main outlet for the products of the tin-box industry. The only available information on the use of tin boxes for containers for non-processed food or for products other than food is contained in the "purchases" sections of the 1948 Census of Production reports—from which I quoted the statistics in Table 11.

Although I have no complete statistics at my disposal which I can make public in this paper, I can say with certainty that the main uses of tin boxes or containers for non-processed foods are for biscuits, milk powders (baby food), syrup, confectionery, coffee and cocoa. In the packaging of products other than food, the main packs are paint, tobacco and cigarettes (mostly for export), medical and pharmaceutical supplies and polishes.

Further statistical research is at present being carried out in the field of the uses of tin boxes other than for processed foods and also in the uses of tinplate other than for containers for packaging. Apart from confidential official records this field of research is almost entirely unexplored, and it is believed that in due course there may well flow from it statistics covering many aspects of the distribution of consumer goods which will be of value both to the economist and to others engaged in the planning of business activities.

7. Future Demand and Supply.

The development of the tin and can manufacturing and canning industries has, in almost every country in the world, been retarded by a shortage of tinplate since 1945. This section of my paper attempts to examine the likely supply and demand for tinplate throughout the world during the next four years with a view to assessing whether the current increases in tin-plate manufacturing capacity will be sufficient to meet the demand.

Table 27 gives an estimate of tinplate production in the main producing countries. This table has been based on the information which is available on new capacity which is scheduled to come into operation by 1955. The background detail of the information is shown in more detail in Table 28.

In Table 29 I show the consumption of tinplate in the consuming countries throughout the world and I make an estimate of demand in 1955.

Graphs 3 and 4 combine these estimates of supply and demand and indicate the extent of the gap between them in (a) the World, and (b) Europe.

I should like to make it clear that in assessing demands for tinplate I have made what is essentially a commercial judgment rather than relying on purely econometric methods. I am not challenging the general validity of the econometric approach but for this particular problem where the forecast is relatively short-term and where the demand has been frustrated for so long, I think it sounder to make my estimates on the basis of commercial intelligence rather than on a more theoretical technique.

Table 27

(1) The figures below do not make any allowance for the projected Australian plant, which will not be in operation during the period under review.

(2) The figures for "iron curtain" countries are estimates. No figures have been included for the U.S.S.R., nor for the eastern zone of Germany.

(3) India could increase production to 85,000 tons if she were assured of additional supplies of tinplate bars.

(4) Of the estimated Belgian output, not more than half is expected to be tinned. Similarly, whilst the new Italian plant will have a nominal capacity of 150,000 tons, its entire production is expected to be diverted to sheets.

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TABLE 27—*continued*

Tinplate: Estimated Production of Main Producing Countries
(Thousand long tons)

Continent	*Country*	1951	1952	1955
America	Brazil	42	60	80
	Canada	246	275	300
	Chile	12	15	20
	Mexico	12	12	20
	*U.S.A.	5,000	5,400	6,000
Europe	*Belgium	24	70	120
	*France (including Saar)	200	230	300
	*Western Germany	250	275	325
	Italy	58	60	75
	Netherlands	Nil	Nil	74
	Norway	8	10	10
	Spain	15	20	20
	*U.K.	757	850	950
	"Iron Curtain" Countries (excluding U.S.S.R.)	40	60	100
Asia	India	70	70	70
	Japan	94	100	150
Africa	Union of South Africa	10	25	30
		6,838	7,532	8,644

* Production figures marked with an asterisk include blackplate.

TABLE 28

Tinplate Production Capacity

America

Country	*Installed*	*Being Installed or Definitely Planned*
U.S.A.	Current production rate 5,000,000 tons per annum	The following are the known projects, their dates of commencement of operation and capacities: U.S. Steel Corporation — Trenton, 1952, 350,000 tons; Pittsburg, Calif., early 1952, 150,000 tons. Jones & Laughlin, Pittsburgh, early 1952, 200,000 tons. Kaiser Steel Corporation, Fontana, 1952, 200,000 tons.
Canada	Current production now at 246,000 tons per annum following running-in of new mill at Hamilton	
Argentine		Proposed new mill unlikely to commence operating for several years.
Brazil	Current production 42,000 tons per annum	Volta Redonda project includes continuous hot and cold strip mills. Planned capacity available 1952: 50,000 tons Electrolytic, 30,000 tons Hot-dipped.

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TABLE 28—*continued*

Country	*Installed*	*Being Installed or Definitely Planned*
Chile . .	An old mill bought from Canada now in operation. Capacity 18,000–20,000 tons	
Mexico . .	Current production 12,000 tons	Existing plant at Monclova being modernized and expanded to capacity of 20,000 tons.
	Europe	
Austria . .		New hot and cold strip mills at Linz with tinplate capacity of 36,000 tons expected to be in operation in 1953.
Belgium . .	Phoenix Works, Capacity 25,000 tons	Ferblatil plant (capacity 70,000–80,000 tons) still at "running-in" stage.
France (including Saar)	Current production 200,000 tons	When the new mills being erected by Sollac are in operation, total French production should be 300,000 tons.
Western Germany	Current production 250,000 tons	Andernach—New 4-Stand mill planned to produce strip up to 800 mm.
Greece . .		Sheet and tinplate mill, financed by American Aid, under construction at Piraeus.
Italy . . .	Production at rate of 58,000 tons tinplate is well below the 1939 level of 94,000 tons	The entire capacity of a new Italian plant (150,000 tons) is expected to be diverted to sheets.
Netherlands .		Koninklijke Hoogovens en Staalfabrieken at Ijmuiden plans a tinplate plant with a capacity of 74,000 tons. The equipment has been ordered. Scheduled to commence 1953.
Norway . .	Current production 8,000 tons per annum is believed to equal present capacity	Modernization of Simonsvik mill should increase production by 2,000 tons per annum.
Portugal . .		Companhia Portuguesa de Siderurgia is reported to be erecting a plant for manufacturing tinplate, but in its initial stages will be confined to tinning imported blackplate.
Spain . .	Tinplate production at 15,000 tons in 1949 was well below capacity owing to lack of steel and coal. 1938 production 35,000 tons	Efforts have been made to form a national project but nothing concrete has emerged.
United Kingdom	Current production 750,000 tons	Trostre now running-in. Estimated annual output 300,000 tons rising to 400,000 tons. Electrolytic tinning plant should be in operation late in 1952.
	Asia	
India . .	Current production 70,000 tons per annum. Limiting factor is supply of tinplate bars	
Japan . .	Current production at 94,000 tons is well below the peak figure of 180,000 tons in 1938	Toyo Kohan Company have placed orders for a small cold strip mill and are improving existing plant. Yawata Company are modernizing existing plant.
	Africa	
Union of South Africa		New Iscor plant, with capacity of 30,000 tons opened in 1951. This plant is still being run-in.
	Australasia	
Australia .		Port Kembla project. Planned production 100,000 tons per annum. Will not be in operation for several years.

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GRAPH 3.—World tinplate: Estimated production and demand.

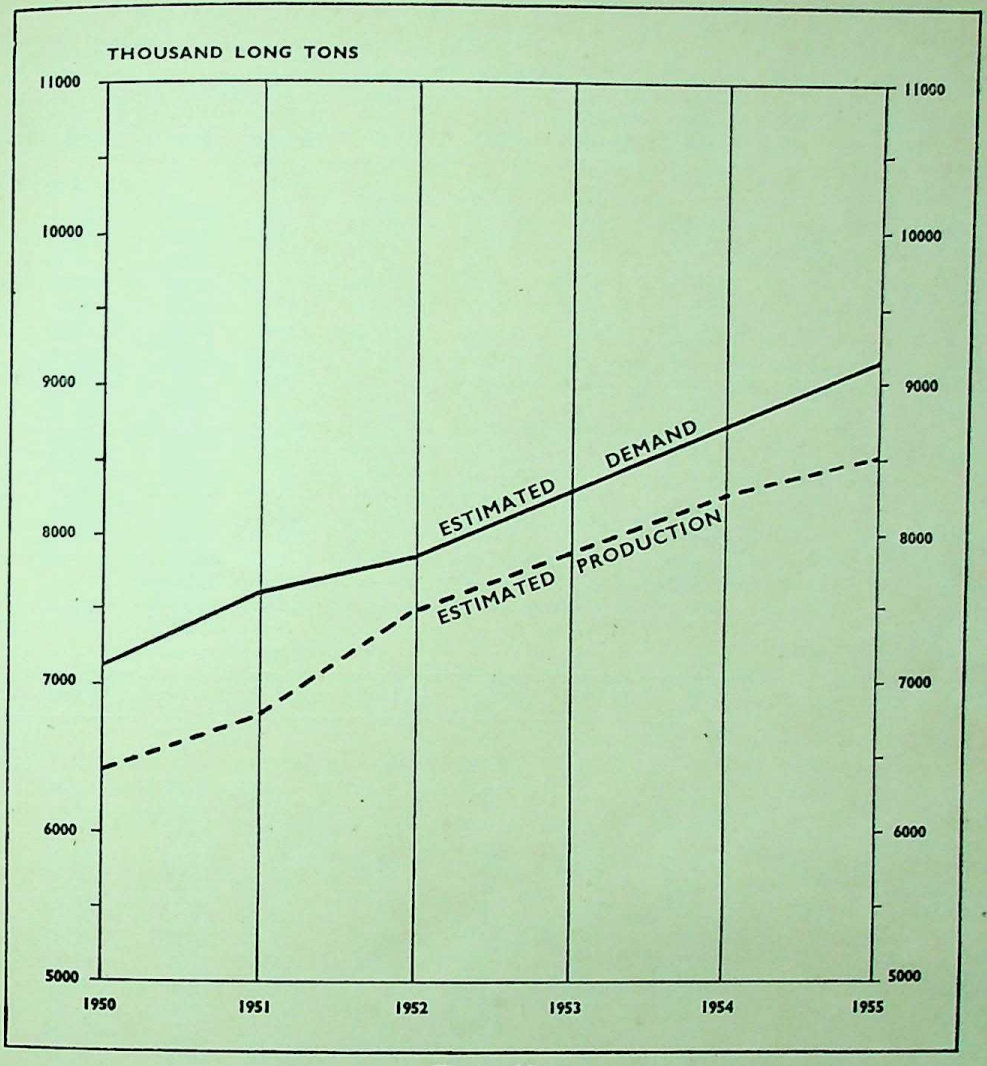

TABLE 29

Tinplate—Apparent World Consumption and Demand

(*Thousand Long Tons*)

America

Country	*Apparent Consumption*						*Estimated Demand*	
	Pre-War Average 1935–38	*War Years Average* 1940–45	1949	1950	*Highest ever*	*Year*	1952	1955
Argentine	62·3	55·6	34·4	57·8	90·7	1941	100·0	150·0
Brazil	41·8	51·5	65·2	84·2	84·2	1950	120·0	150·0
Canada	99·8	132·2	184·6	213·1	213·1	1950	220·0	250·0
Chile	6·6	8·2	9·6	3·6	11·6	1948	13·0	15·0
Colombia	3·0	2·8	3·5	5·6	5·6	1950	6·0	7·0
Cuba	9·2	14·0	11·0	17·9	22·1	1947	25·0	30·0
Mexico	13·3	15·6	20·4	16·8	20·4	1949	24·0	30·0
Paraguay	0·2	2·1	2·3	0·7	4·5	1942	3·5	5·0
Peru	5·2	3·1	2·5	2·8	6·4	1940	6·0	10·0
U.S.A.	1,900·0	2,600·0	3,200·0	4,350·0	4,350·0	1950	5,000·0	5,750·0
Uruguay	6·6	11·3	7·3	8·5	17·1	1940	10·0	13·0
Venezuela	0·9	2·0	0·9	2·0	4·1	1948	4·5	6·0
Total America	2,148·9	2,898·4	3,541·7	4,763·0	4,829·8		5,532·0	6,416·0

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TABLE 29—*continued*

Europe

Country	Apparent Consumption: Pre-War Average 1935–38	War Years Average 1940–45	1949	1950	Highest ever	Year	Estimated Demand: 1952	1955
Austria	—	—	1·8	3·4	—	—	5·0	6·5
Belgium	21·8	1·6	24·1	26·9	34·1	1948	35·0	35·0
Denmark	18·5	1·1	20·8	31·8	31·8	1950	30·0	35·0
Eire	5·9	3·9	5·8	5·3	7·9	1940	8·0	11·0
Finland	2·4	0·3	1·8	5·6	5·6	1950	4·0	6·0
France	104·8	24·5	92·1	114·7	128·1	1937	240·0	300·0
Germany	128·9	185·8	155·0	155·0	210·0	1940	175·0	200·0
Greece	7·8	1·2	5·7	9·2	9·2	1950	10·0	13·0
Italy	51·5	22·5	59·4	78·7	84·8	1937	160·0	160·0
Netherlands	58·5	7·1	67·8	76·3	76·3	1950	100·0	125·0
Norway	26·5	4·0	24·4	29·0	33·3	1937	33·0	40·0
Portugal	22·3	17·3	13·1	4·0	27·9	1937	40·0	52·0
Spain	38·4	9·8	16·7	22·3	58·5	1938	55·0	75·0
Sweden	17·1	7·1	30·9	23·0	30·9	1949	34·0	40·0
Switzerland	12·9	2·1	12·0	13·1	16·3	1948	20·0	25·0
United Kingdom	396·7	530·0	537·0	516·0	634·0	1942	680·0	800·0
Yugoslavia	4·5	0·2	0·8	2·4	5·5	1939	3·0	8·0
Bulgaria	3·2	0·1	—	—	4·1	1939		
Poland	9·8	—	—	—	13·3	1937	55·0	65·0
Czechoslovakia	7·7	—	—	—	9·6	1937		
Hungary	—	—	—	—	—	—		
Total Europe	939·2	818·6	1,069·2	1,116·7	1,421·2		1,687·0	1,996·5

Asia

Ceylon	—	—	2·4	1·6	2·4	1949	4·0	5·0
China	47·2	7·8	4·5	6·4	45·6	1937	17·0	25·0
Hong Kong					21·6	1937		
India	58·3	35·6	100·4	88·2	100·4	1949	115·0	135·0
Indo-China	6·0	1·2	1·7	3·5	10·1	1939	3·5	5·0
Indonesia	24·1	10·0	5·2	3·5	33·5	1940	15·0	20·0
Iran	7·7	12·8	7·0	8·7	53·0	1943	10·0	12·0
Iraq	—	—	2·0	0·5	2·0	1949	2·0	3·0
Israel	2·0	2·6	4·3	2·8	8·3	1941	5·0	8·0
Japan	184·6	78·2	34·9	65·0	215·6	1937	125·0	150·0
Malaya	21·5	6·0	10·4	11·6	26·6	1937	15·0	20·0
Pakistan	—	—	9·1	9·4	9·4	1950	11·0	15·0
Philippines	8·9	3·3	10·4	13·9	16·3	1939	15·0	20·0
Turkey	7·0	3·3	10·6	14·2	14·2	1950	15·0	18·0
Total Asia	367·3	160·8	202·9	229·3	559·0		352·5	436·0

Statistics for India prior to 1949 include Ceylon and Pakistan.

Africa

Algeria	1·2	0·6	2·8	2·6	3·4	1948	*	*
British East Africa	1·1	5·6	8·8	5·4	9·5	1942	12·0	20·0
British West Africa	3·4	1·6	4·1	6·7	7·0	1939	7·0	9·0
Egypt	8·7	15·0	7·0	4·7	43·2	1942	8·0	10·0
French Morocco	4·1	2·0	16·6	12·5	16·6	1949	*	*
Southern Rhodesia	0·4	0·3	—	0·5	0·8	1946	1·0	2·0
Sudan	2·1	1·1	2·1	4·1	4·1	1950	4·5	6·0
Tunisia	—	—	1·8	1·1	1·8	1949	*	*
Union of South Africa	18·2	27·7	35·4	56·0	48·6	1948	70·0	80·0
Total Africa	39·2	53·9	78·6	93·6	135·0		102·5	127·0

* Included in France.

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TABLE 29—*continued*

Australasia

Country	Apparent Consumption: Pre-War Average 1935–38	War Years Auerage 1940–45	1949	1950	Highest ever	Year	Estimated Demand: 1952	1955
Australia	71·7	110·9	115·1	109·2	123·7	1944	140·0	170·0
New Zealand	12·0	20·1	23·2	14·3	35·5	1943	35·0	50·0
Total Australasia	83·7	131·0	138·3	123·5	159·2		175·0	220·0
Total America	2,148·9	2,898·4	3,541·7	4,763·0	4,829·8		5,532·0	6,416·0
Total Rest of World	1,429·4	1,164·3	1,489·0	1,563·1	2,274·4		2,317·0	2,779·5
World Grand Total	3,578·3	4,062·7	5,030·7	6,326·1	7,104·2		7,849·0	9,195·5

Notes

Figures of past consumption for U.K., U.S.A. and post-war Germany include estimates of blackplate. Other figures are, in general, as published in the *Statistical Bulletin of the International Tin Study Group* and are for tinplate only.

All estimates of future consumption include allowances for blackplate.

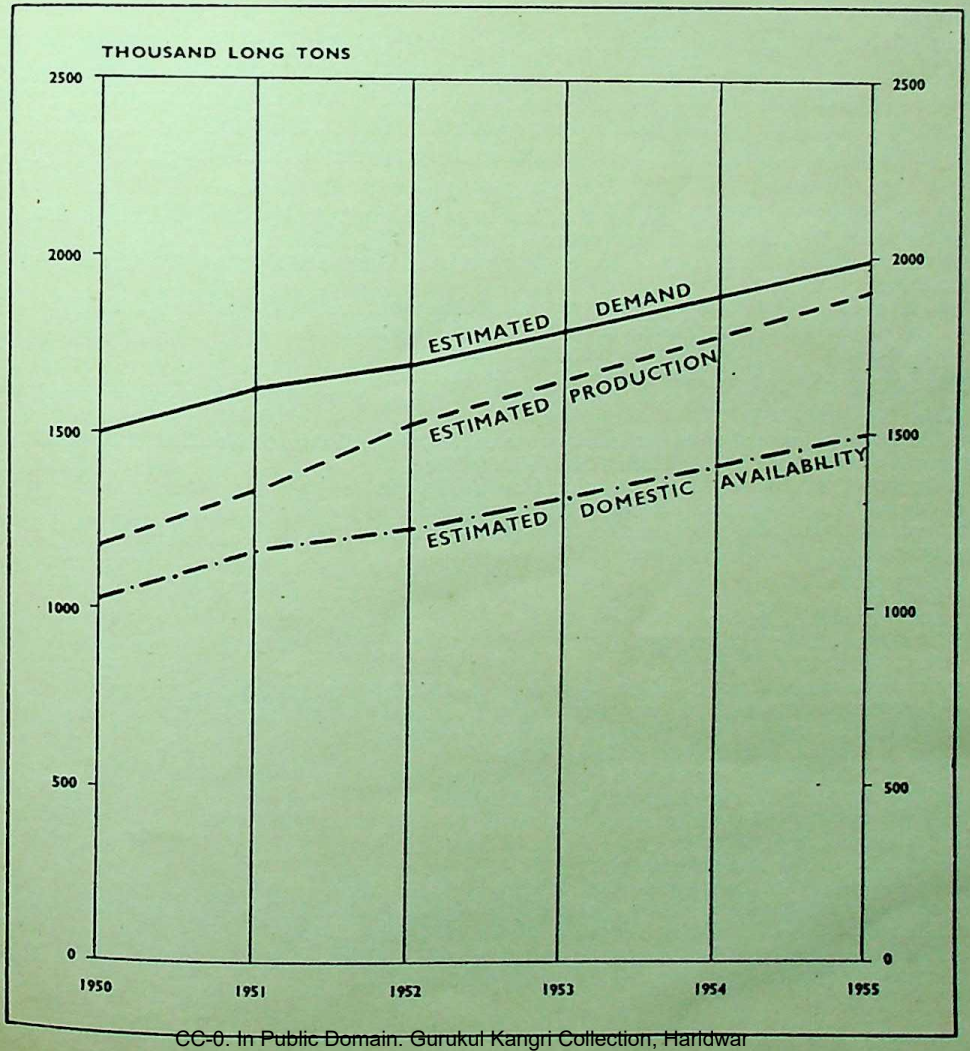
No estimates or statistics are included for U.S.S.R.

Demand figures for France and Belgium include demands of overseas dependent territories.

Figures for Germany prior to 1945 refer to the whole of Germany.

Figures for subsequent years refer to Western Germany only.

GRAPH 4.—European tinplate: Estimated production, demand and domestic availability, after allowing for exports (chiefly from the U.K.) and imports from U.S.A.



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The estimates of production are based on the assumption that crude steel will be freely available. The official policy in the U.K. is to make steel available for the new tinplate manufacturing capacity, but if either in the U.K. or elsewhere in the world shortage of crude steel should curtail production, the gap between supply and demand will be so much the wider. The tin-box industry has sufficient excess capacity both in the U.K. and abroad to fabricate the increased supply of tinplate which is likely to be produced. The true demand in most countries for tinplate and for tin boxes has been frustrated by quotas and packaging restrictions, and my estimates of demand have been formulated after considering the purchasing power which is likely to be available to make that demand effective.

These tables demonstrate beyond reasonable doubt that the demand for tinplate is likely to excced the supply for some years ahead. Since from the nature of the large scale plants increases in tinplate production tend to take place in surges and not at a uniform rate, and since following such rapid increases in production the whole of the pent-up demand may not be able to make itself felt immediately, it is possible that at isolated times the gap between supply and demand may appear to be much smaller than my graphs indicate, and it may be that we are shortly approaching such a position. The narrowing of the gap on such isolated occasions should, however, be only temporary, and I believe my estimates represent a fair long-term representation of the difference between supply and demand.

The corollary of this is, of course, that steps need to be taken now to plan and initiate a further increase in the capacity for tinplate manufacture if the frustration of demand from which we have suffered for the past seven years is not to be continued indefinitely. In particular, it emphasizes the need for the United Kingdom to modernize its own tinplate industry and thus make the whole of its production technically efficient.

I should like to express my thanks to the Metal Box Company Ltd. for permission to use its statistics, as well as to its overseas subsidiaries, associates and correspondent companies for the help which they have given over a number of years, both in furnishing statistics and in advising on their interpretation. I should also like to thank Mr. D. J. Liston and Mr. G. C. C. Chivers, both Fellows of the Society, for their assistance in the preparation of this paper.

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Discussion on Mr. Ryan's Paper

Dr. Rostas: There is a lack of factual information relating to the smaller specialized industries, of which the tin box and canning industries are good examples, and I feel that the author deserves our gratitude for bringing this subject forward. The tin box industry has shown a tremendous expansion over the past generation. Even in the period between 1935 and 1951, when its expansion was hindered by lack of tinplate, its output expanded more quickly than the manufacturing industry in general. Moreover, this is an industry providing employment on an increasing scale; it has a high added value per worker and, as the figures in the paper show, is exporting in one form or another about one-fifth of its output. It is obvious that to discover the forces behind the expansion of British industry in general we must study the forces behind the development of such specialized industries.

The paper contains much valuable information on production, export, and home consumption of the tinplate, tin box and canning industry, and much of this information is new. I hope I do not appear ungrateful when I say that the information given whets our appetites for more. We should like to know much more about the structure, organization, market structure, development of prices, costs, productivity, etc., of the tin box industry. Such information, jointly with what the author has given, would enable us to solve such practical problems as those raised in section 7 of the Paper. The most interesting table, to my mind, is Table 7. This, with the supplementary Tables 10 and 12, give an excellent picture of the product breakdown and of the end-uses of the products of both the tinplate industry and the tin box industry. I think it is highly significant that the author attaches such importance to data of this kind. Mr. Ryan directs attention to the flow of goods and products from one industry to another in a way suitable for scientific study, as the papers by Dr. Barna and Mr. Saunders read to the Society in the current session have also done. He has demonstrated that this is a subject of great interest not only to the Government and the academic research worker, but also to the whole industrial community.

For the tin box industry the author has relied mostly on figures for current years. One would have liked a little more historical perspective, and it is a pity that Mr. Ryan did not make more use for this purpose of the Censuses of Production, although he acknowledges the value of Census reports in an industry which would otherwise be ill-provided with statistical information. I find the Census data invaluable in my studies in industrial economics, although I agree with Mr. Ryan that there are innumerable pitfalls in the use of such data. Mr. Ryan refers to such pitfalls in section 4 when dealing with the output data as derived from the 1946 Census. These pitfalls—I would not call them "anomalies"—result from the type of approach which the Census necessarily applies, namely, the collecting of information on an establishment basis. In consequence there is bound to be duplication in the value of the output of the types mentioned by Mr. Ryan, because some intermediate products are lumped together or listed together with the final products. The Census Office usually takes a great deal of trouble (though this was not done in the partial Census of 1946) to eliminate duplication and to calculate gross output data free of duplication. As far as I am aware this is being done in the 1948 results. Also because of the establishment approach, the output of containers by manufacturers of canned foods, biscuits, etc., who use them themselves to pack their products, does not appear as a separate item in their final output—another and perhaps more important pitfall in the Census data mentioned by Mr. Ryan. If the ascertainment of such output is important, the only way to deal with it is to collect the information as an additional item on the questionnaire. This has already been done in the 1948 Census for chocolate, cocoa and sugar confectionery and some other trades and, I understand, may be extended further. Such pitfalls do not by any means reduce the value of the Census information. Nevertheless Mr. Ryan does good service to call attention to them. Indeed it is for the industrial experts to keep the Census Office up to date about changes in industrial practice, to which the statistical procedures can then be fitted to get the best figures for the benefit of all users, including the academic research worker.

My last point refers to section 7 of the Paper, perhaps the only controversial part of it. Here Mr. Ryan looks into the future and provides estimates of future production and future demand and supply. The estimates of future production are based on the fairly solid foundation of capacity already installed, being installed or definitely planned, and on the less solid foundation of assuming free availability of crude steel. When it comes to future demand for tinplate Mr. Ryan puts out a challenge when he says that in assessing demand he has used commercial judgment rather than relied on purely econometric methods, because, for a relatively short time and where demand has been frustrated for so long, it is sounder to make an estimate from commercial intelligence rather than to depend on a more theoretical technique. It is a great pity, however, that Mr. Ryan does not disclose exactly how this sounder commercial judgment is formed, as this would greatly benefit

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the econometrician. I suspect that many of the factors which are taken into account in forming a commercial judgment would also be taken into account by econometricians. Looking at the estimates of future demand I am somewhat perplexed. Is the final column in Table 29 an estimate of the amount of tinplate which the author expects will actually be consumed in 1955, or does it refer to the amount which should be consumed if only world conditions were different? I notice that Europe is expected to consume 80 per cent. more tinplate in 1955 than in 1950 and the United Kingdom about 55 per cent. Will there be enough demand for such increases? The U.K. figure also implies that a great deal more tinplate will be exported in 1955 in the form of packaging for exports of, say, biscuits and tobacco, and (unless I misread the figures) the paper assumes that the United Kingdom will export in 1955 less tinplate in its crude form than at present. Is this realistic? The author says that the tin box industry has got the excess capacity to process this increased supply of tinplate. But does he mean that labour will also be available, or does the existence of excess capacity merely imply the possibility of widespread shift working? Then there are the potential implications of competition from other types of packaging such as glass and fibre; also the more widespread use of quick freezing of foodstuff. Nothing is impossible in this industry in view of the tremendous progress which has taken place in the past, and I should like to ask Mr. Ryan to elaborate a little on how he has arrived at the estimates which would also support his suggestion that the demand for tinplate is likely to exceed the supply for some years ahead.

To sum up, this is a valuable paper, informative, and one which makes an important contribution to our knowledge of the industry. It gives me great pleasure to propose a vote of thanks.

Mr. Vibart (in seconding the vote of thanks): The Paper contains a considerable bulk of valuable information on a wide range of subjects—information not previously available in a convenient form of this kind setting out the various items in due relationship to one another.

On p. 468 it is said that "in 1951 more than 70 per cent. of British tinplate was still being produced by methods not substantially different from those used 150 years ago." This is a dramatic and arresting statement, and it is easy to understand what Mr. Ryan had in mind, namely that the earlier completion of a second strip mill would have been a very valuable factor in improving the supply of cold reduced tinplate. At the same time in my view it is a misleading statement, misleading in the first place because so much depends on the meaning to be attributed to the word "substantial", for apart from the strip mill there are many changes of process which can probably be described as substantial. To take a single example, it would surely be a misuse of words to say that there was not a substantial difference between a Melingriffith automatic pickling and tinning machine which puts on a lighter coating on 6/7,000 basis boxes a week, and the old hand-dipping pot that took perhaps six months to complete what is now a week's output for the modern Melingriffith machine.

Again, this description must surely be misleading when it is remembered that an exactly similar remark could have been used with literal correctness in describing the tinplate industry of the United States for the year 1936, when 75 per cent. of the American tinplate output was made by other than strip mill methods, but who would venture to describe the U.S. tinplate industry as unprogressive?

On p. 475 the author mentions that the tin box industry covers some 40,000 employees and has an invested capital of about £25,000,000. It is interesting to compare this figure (about £625 per employee) with those for a modern integrated steel plant where the capital required to set a man to work is about ten times as great.

Tables 13 and 16 are particularly interesting and I hope the author will explain their relationship, e.g., is one set of figures to be regarded as the complement of the other? This seems to work out well in the case of paint, but not in other cases, e.g., talcum powder. Some additional information would be very helpful.

On the question of scrap cans (pp. 481–482) the author says "A steel scrap collection of little over 30 per cent. of potential cannot be regarded as satisfactory in these times of steel scrap scarcity". This statement does not present a balanced picture, since he omits any reference to the efforts being made by the steel industry and others to increase the effectiveness of the methods of collection and to widen the scope of collection. In 1951 it was possible to induce 300 additional local authorities to undertake segregation and collection of scrap tins, thus increasing the total number co-operating in this way from 200 at the beginning of the year to 500 at the end. The 500 local authorities covered areas containing approximately half the total population of the country, so it is reasonable to assume that the 30 per cent. will be substantially improved upon in the current year if the need for scrap remains as great as at present.

This brings me to what is probably the most important section of the paper, namely, Mr. Ryan's estimate of the future world consumption of tinplate. Mr. Ryan obviously has an unrivalled opportunity for gaining knowledge of this problem and, therefore, any view which he expresses

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is to be regarded with the utmost respect. Apparently he contemplates an average increase of about 7–8 per cent. per annum over the five years 1951–55, and accordingly I feel that it would be valuable if he would comment on the significance of the fact that in the first of these years, namely 1951, reported world consumption did not show any advance on 1950, and that in America the consumption figure was actually down by about 8 per cent. In order, therefore, to fulfil Mr. Ryan's estimate it would be necessary for the increase in ensuing years to be proportionately greater than the average which is contemplated in the Paper.

One point which I hope may be mentioned later in the discussion is the significance, if any, in the States or elsewhere, of the deep freeze method. Is this going to be a material influence on tinplate consumption?

The vote of thanks was put to the meeting and carried unanimously.

Mr. HOARE, after thanking Mr. Ryan for a most valuable compilation of statistics, said he would like to take up one or two quite minor points. It was stated that during 1951 the overall "basis box/ton" ratio for United Kingdom production of tinplate, blackplate and terneplate was 21·97. This, he believed, was considerably lower than the average for the United States. If one studied such published data as were available for the States it seemed to indicate that the figure of 24·6 basis boxes might be more appropriate for that country. He would like to know whether the author's experience confirmed that figure. If that figure were correct, there was a possibility of making a greater useful area of tinplate in the country without consuming any more steel. Tinplate was used, broadly speaking, for its area, not for its weight. Admittedly such questions as variation of substance must be kept in mind, and the more modern concept of temper must not be forgotten. But there was some possibility that something like a million more *boxes* of tinplate might be made without making any more *tons* of tinplate.

Mr. Ryan had said that the first tinplate can with a steel basis came in about 1912. The present speaker thought it must have been perhaps ten years earlier than this, because steel was being made and used for tinplate in quite a large quantity even before the turn of the century.

He was particularly interested in the breakdown figures which the author gave for the use of tinplate in the various packaging fields, and these did enable certain inferences and judgments to be drawn which were not previously possible. This was a very valuable section of the paper.

The tinplate and canning industry was undergoing world-wide development. It was developing increased manufacturing facilities, and its products were being sold in areas which had widely different marketing habits and consumer demands. It had to adapt itself to the requirements of many different products calling for different types of packaging. In forward planning the value of the information presented in this paper could not be too highly stressed.

Mr. JOHNSON said that all who had occasion to use tinplate or canned food statistics owed a debt of gratitude to the author for his paper. To give as complete a picture as possible, Mr. Ryan had had to make estimates where published figures were not available. It was only fair to say to Mr. Ryan that where it was possible to check his estimates against unpublished records, these estimates were found to be at least as reliable as published information.

He then made some further references to the difficulties which were encountered in the preparation and use of statistical information in this field. For example, food which was canned at the end of May might have been packed in cans which were received in April. These cans might have been made from tinplate delivered in February, and the corresponding tinplate bars might have been received at the tinplate works during the previous December. The time interval between receiving the tinplate bars and the packing of the canned product might, therefore, be as long as six months, and emphasized the necessity for long-term planning through all stages.

In order to learn how well our long-term planning had worked out in the past, statistical information must be clear and free from ambiguity. Thus we might know what was canned in a certain week and how much tinplate was made for food cans in that week, but these two figures are related only by the date on the calendar. It was necessary to go further back to establish a true relationship between tinplate production and canned food production. The author had pointed out that these differences disappear if a long enough time basis was taken and stock changes were negligible, but in view of seasonal fluctuations in the production of many kinds of canned food it was necessary to plan on a shorter time basis than twelve months.

The relationship between canned food and tinplate production might be complicated in future by the fact that aluminium was entering into the container field.

The author and other speakers had referred to the great difficulty which arose from the use of different units relating to both weight and area. Further, tinplate production statistics may refer to the amount of tinplate rolled in a given period, the amount of tinplate invoiced in that period or the amount delivered, and difficulties arose from the fact that mill output, tinplate invoiced and tinplate delivered in a period could differ appreciably.

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He hoped that the paper would stimulate the various sections of industry to get together in an attempt to rationalize the recording of production, so that statistics for the different sections could be brought into closer correspondence.

Mr. IRELAND congratulated the author on the extensive ground he had covered. His figures for home consumption would be very helpful to all those engaged in this industry. The most important point brought out by the author seemed to be the progress of the British tinplate industry, which in the last century led the world, whereas in this century it had made no progress at all, and we were producing now the same amount as at the beginning of the century. This contrasted with industries growing up in other countries. In America in 1950 the increase in tinplate production over the previous year was greater than the whole of the production in England. When the importance of tinplate as an export was considered, and its value to the under-developed countries abroad, one could realize what a great contribution it might have made in solving the balance of trade difficulties of the last few years. He thanked the author for his figures.

Mr. LEWIS said that one point had struck him had been emphasized by what Mr. Johnson had said, namely, the time lag between planning the tinplate and getting it. With cans the time lag was five months, and with tinplate production even longer. If there was going to be an increased supply of containers, so that there could be greater production of food in canned form, the tinplate must be ready before the food instead of having the food first. As there was a time lag of about four years before getting the benefit from plans for a tinplate plant, it was important to make plans soon.

Mr. J. R. GREEN said that the paper was a most interesting contribution on what to a non-statistician like himself might be a dry subject.

The author probably knew, though most of his audience did not, that the collection and detinning of used cans was seriously considered ten years ago. These tins were widely dispersed, bulky, and dirty. If housewives would clean and flatten the tins and separate them from other refuse, and if local authorities would collect them separately, some of the difficulties would have been met. The marketing of the detinned scrap might, for technical reasons, need careful consideration. His own, minimum, estimate of the available tonnage was 120,000 tons per annum of cans.

The date of the manufacture of tin cans from tinplate had been questioned; his own impression was that it was a good deal earlier than 1912.

He agreed with Mr. Ryan that until Ebbw Vale very little basic change had taken place in the character of the tinplate-manufacturing industry; certain mechanical devices had been introduced, but the amount of hard manual labour required in the old process was and remained extraordinary; it was not uncommon to find men "worked out" at the age of 45 or so.

Mr. LISTON said that arising out of the remarks of Mr. Vibart he would like to make a comment on the consumption of tinplate in 1951 in the United States. One had to bear in mind that 1951 was a rather extraordinary year in that country. Production was going up, but there was also a determination on the part of the United States authorities that what tinplate was produced should be used as part of the defence production. In addition they were fighting a stiff war over the price of tin. As a result, very strict controls were imposed in the United States, and that had the extraordinary effect that in 1951 the output of tinplate was in fact greater than could legitimately be used for the permitted purposes, largely owing to the lag in the defence programme. The 1951 consumption figures in America were not a useful guide to the foreseeable level of demand in that country in future years.

Mr. J. RYAN, in reply, said that Dr. Rostas had dealt with the value of the census. In the paper he made it plain that the census indeed contained much valuable material for those who had the training and knowledge to extract it. He paid tribute to the Board of Trade, who were very ready to improve the information given, and to make it more easily available. As he had said in his summary, the 1948 figures, which he would give in fuller detail in writing, did go some distance towards this end. There was a long way to go yet, and a problem requiring consideration was how much to disclose to those who had enough specialist knowledge to fill in the gaps.

He had found Dr. Rostas stimulating on the question of his definition of estimation of demand. He was naturally not prepared to show all the mechanics of the processes used to obtain the commercial forecasts on which the success of their industry depended. The short answer to Dr. Rostas was that in arriving at his figures he had taken into account as far as he could all the possibilities in all the directions he had mentioned. Obviously factors whose existence was unknown

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had to be omitted. All known factors were used, and as he had said elsewhere every one of us knows very much more about the future than he thinks he does. The "inevitability of gradualness", the margin of error, and that sort of thing helped to keep one right.

He would look into the difficulty mentioned by Mr. Vibart in relating Tables 13 and 16. As for the problem of scrap can collection, the collection of scrap cans in 1952 would not, he thought, differ substantially from 1951. His target was based on the amount of tins and cans sold over the counter, which he had learned, and had been able to substantiate by his own researches, was about 8 tons per 1,000 of population per annum. London's best example of collection was at Tottenham at about this figure. Bury made 9 tons, but the official target was only 5 tons in municipalities and 2 tons in the rural areas. He was conscious of the difficulties of collecting more than at present. As far as he could see, this country was doing better than any other in this respect, including America. For many years it had been said at Government levels that this must be done, but it was not and never would be an economic proposition on a grand scale.

On the question of 1950–51 figures, Mr. Liston had given the main answer. There were good explanations for some of the differences in the weight of the basis box in England and in America, but for certain of the major uses Americans employed, apparently with equal success, a lighter plate than was common in this country. Thus to that extent one was not really comparing like with like.

He was glad to feel from the remarks which had been made that there had been value in bringing together much of this information from a variety of sources; and if this paper could be used as a starting-point for further investigations and developments by statisticians, and if there was any value in the caveat he had put in with regard to some of it, then he felt his effort had been amply repaid.

Mr. RYAN subsequently replied in writing as follows:

Dr. Rostas felt that the interpretation of the figures on future tinplate production and demand might be confused, and it is perfectly true that an estimated demand is shown in the United Kingdom in 1955 of 800,000 tons and estimated production at 950,000 tons. It is not true, however, to suppose that I draw the conclusion from this that we shall be exporting less crude tinplate in 1955 than we are doing to-day. In fact, unless British tinplate production increases our exports will presumably be maintained and home demand will continue to be frustrated. The probability is that home production will be increased by the building of a further strip mill and so help to offset the loss of the old hand-mills. It is doubtful, however, whether such a mill can be operating before 1955.

In reference to Mr. Vibart's remarks, there is no real discrepancy between Tables 13 and 16. Table 13 shows conversion factors by value between the tinplate content of filled containers and their F.O.B. value when filled. Table 16, on the other hand, shows the cost of a container as a percentage of the retail selling price of the packed article.

For talcum powder the tinplate content is a relatively small percentage, as the tin itself is heavily decorated and contains a good deal of conversion value, whilst talcum powder tends to be sold at fairly high prices. This is particularly so for the types of talcum which are exported, so that it is perfectly logical that the tinplate content of a tin of talcum powder sold for export should represent only 4 per cent. of the F.O.B. value of the exported article, whereas the cost of a container should be as high as 19 per cent. of the retail selling price of a tin of talcum powder sold in this country.

In reply to Mr. Hoare, I accept the fact that the United Kingdom might well use lighter substances in the future. It is certainly the trend, and possibilities for further progress in this direction undoubtedly exist. I agree from further examination that the first tinplate can with a steel basis should more accurately be placed about the turn of the century, rather than in 1912, as I originally stated.

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Edward Lewis Bedford.
Charles Henry Gerald Bostock.
Derrick Alan Brace.
Wilfred Harold Brooks.
Walter Eric Duckworth.
Walter Frank Gardner.
William Moore Gorman.
John Allan Hargreaves.
Gerald Arthur Vernon Leaf.
P. Krishna Moorthy.
Henry Nowik.
Alastair Bateson Lindsay Smith.
Peter Harold Smith.
Kenneth Ascough Usherwood.

Corporate Representative

H. W. James English, *representing* The Chartered Bank of India, Australia and China.

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Index-Numbers of Wage-Rates and Cost of Living

A. L. Bowley

The index-number of wage-rates, published seriatim in the *Bulletin of the London and Cambridge Economic Service*, is not easily accessible in its complete form. The series has for various purposes been adjusted to different basic dates and there have been minor amendments as belated data have become available. There is a risk of misquotation and unnecessary trouble to students. Consequently it appears to be worth while to publish the series *in extenso*.

The existing series is based on data assembled for December, 1924, which were described in detail in the London and Cambridge Special Memorandum, No. 28, 1929 (1), and there has been no essential change in its weighting system or general construction since then. There have been difficulties since 1940 in keeping exactly to the definition, when in wage-awards percentage changes have been replaced by flat increases for all, or the nature of the data has changed, or there has been confusion between piece and time rates. Somewhat similar difficulties are to be found in the Sauerbeck-Statist wholesale price index. Except in the series for coal, and to a less extent for cotton, such ambiguities have only negligible effects on the general average.

For the basis of the index 20 industries or occupations were selected for which data were regularly available, and series for each were expressed as percentages of the wage in December, 1924. They were chosen so as to include time and piece-rate payments, skilled and unskilled occupations, men and women, and they were weighted (with some adjustment) by the total of wages shown for each industry in the Census of Production for 1924.

The intention throughout has been to measure the change of wages paid for unchanged work in the number of hours that at each date constituted a normal week without overtime or short time. The series does not measure average earnings which are affected by several other factors. The original figures are set out in Table 1.

Table 1

Wage-rates Index

December, 1924 = 100

	Year									
	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934
Jan. . .	100·4	100·5	101·0	100·5	99·5	99·0	98·3	96·3	94·5	94·0
Feb. . .	100·7	100·5	101·0	100·0	99·5	98·5	97·7	95·7	94·0	94·0
Mar. . .	100·8	100·5	101·0	100·0	99·5	98·5	97·7	95·7	94·0	94·0
April . .	100·9	100·5	101·0	100·0	99·5	98·5	97·0	95·7	94·0	94·0
May . .	100·9	100·5	100·5	100·0	99·5	98·3	97·0	95·7	94·0	94·0
June . .	100·3	100·5	100·5	100·0	99·5	98·3	97·0	95·7	94·0	94·0
July . .	100·5	100·3	100·0	100·0	99·5	98·3	97·0	95·3	94·0	94·0
Aug. . .	100·5	100·3	101·1	99·5	99·0	98·3	96·7	95·3	94·0	94·0
Sept. . .	100·5	100·3	101·1	99·5	99·0	98·3	96·7	95·3	94·0	94·0
Oct. . .	100·5	100·3	100·5	99·5	99·0	98·3	96·5	95·0	94·0	94·7
Nov. . .	100·5	100·3	100·5	99·5	99·0	98·3	96·5	94·5	94·0	94·7
Dec. . .	100·5	101·0	100·5	99·5	99·0	98·3	96·5	94·5	94·0	94·7

	Year									
	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944
Jan. . .	94·3	96·3	99·0	103·7	104·8	110·7	122·9	133·1	139·8	148·2
Feb. . .	94·3	97·0	100·0	104·0	104·8	111·5	125·3	133·7	139·8	148·2
Mar. . .	94·3	97·0	100·0	104·0	104·8	114·5	125·4	134·3	142·1	148·8
April . .	94·7	97·3	100·3	104·5	104·9	115·7	125·9	134·4	142·8	151·3
May . .	94·7	97·3	100·7	104·5	104·9	115·8	125·9	134·4	143·7	153·0
June . .	94·7	97·5	100·7	104·5	105·7	118·2	126·6	135·4	143·7	153·2
July . .	95·7	98·0	101·0	104·5	105·7	119·0	127·6	138·2	143·9	154·0
Aug. . .	95·7	98·0	101·3	104·5	105·7	119·1	127·7	138·3	143·9	154·1
Sept. . .	95·7	98·0	101·7	104·5	105·8	119·4	128·1	138·3	144·0	154·5
Oct. . .	95·7	98·0	102·3	104·5	105·8	119·9	128·3	138·4	144·1	154·7
Nov. . .	95·7	98·0	103·0	104·5	107·9	119·9	128·6	138·3	144·4	155·6
Dec. . .	95·7	98·0	103·0	104·5	109·3	120·8	132·3	138·8	145·2	155·6

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TABLE 1—(*continued*)

	Year							
	1945	1946	1947	1948	1949	1950	1951	1952
	155·8	168·9	178·9	191·4	199·9	204·0	217·6	238·8
Jan.	156·6	170·2	178·9	193·4	200·3	204·6	218·5	241·5
Feb.	156·6	170·6	178·9	194·6	201·4	204·6	220·7	242·3
Mar.	157·6	173·8	180·7	195·3	201·4	204·5	221·4	241·9
April	159·7	174·9	180·9	195·3	201·9	204·5	221·4	242·0
May	161·2	174·9	180·9	195·6	201·9	204·5	222·0	242·0
June	162·2	176·5	183·4	196·6	201·9	204·6	224·0	—
July	163·6	176·5	183·4	196·6	202·5	204·6	224·2	—
Aug.	163·6	176·8	184·8	196·7	202·6	204·7	225·9	—
Sept.	163·3	177·4	185·1	199·6	203·5	205·4	230·6	—
Oct.	163·8	178·2	189·7	199·6	203·5	210·8	237·5	—
Nov.	164·5	178·2	189·7	199·6	203·7	211·2	237·5	—
Dec.								

In February 1949 the series published in the Bulletin was altered proportionately to show the percentage movement in relation to the average of 1938. Since the former index showed 104·3 for that year, the earlier numbers were reduced in the ratio 104·3:100. The yearly averages are shown in Table 2(A).

TABLE 2 (A)

Wage-rate Index

Yearly average. 1938 = 100

Year	*Index*	*Year*	*Index*	*Year*	*Index*
1924	96	1934	90	1944	146
1925	96	1935	91	1945	154
1926	96	1936	93	1946	167
1927	96	1937	97	1947	175
1928	96	1938	*100*	1948	188
1929	95	1939	101	1949	193
1930	94	1940	112	1950	197
1931	93	1941	122	1951	216
1932	92	1942	131	1952	231
1933	90	1943	138		till June

1914–1924.—Before 1924 an index had been published based on the unweighted average of wages in 11 occupations. The details for 1914–20 are to be found in *Prices and Wages in the United Kingdom*, 1914–20, pp. 105–6 (2). During the (first) war period upward movements of wages were very rapid and irregular and the numbers in different industries changed; consequently the average rise over all was uncertain, though the *relative* steps were approximately known. When on the publication of the 1924 Census of Production it was possible to compare the position in 1924 with that in 1914 (3) it was found that the rise in average wages had been underestimated, and that it had probably been about 97 per cent. instead of the 77 per cent. formerly estimated. Working on these estimates we obtain the figures in Table 2(B), which must be regarded as only approximate. They are used in the Ratio Chart here given.

TABLE 2(B)

Approximate Index-numbers 1914–24

	July									
	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
1924 = 100	52	56	62	74	98	119	147	141	109	97	100
1938 = 100	50	54	60	71	94	115	141	135	105	93	96

The great increase during and immediately after the First World War may be compared with that after 1939. The collapse in 1921–22 is striking in the Table and in the Chart. There was considerable variation among the industries and occupations in the amount of increment up to the climax of 1920–21 and of the reaction to 1924; also in the lesser fall to the depression of

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TABLE 3

Weekly Wage-rates Index-numbers Selected Years

Average, 1938 = 100

	Year					
		Maximum		*Minimum*		
	1914	1920–21	1924	1932–33	1938	1952 (*June*)
Building:						
Bricklayers	59	118	102	87	100	206
Labourers	54	164	102	86	100	237
Engineering:						
Fitters	60	137	86	89	100	196
Labourers	48	144	82	86	100	225
Shipbuilding	—	—	93	85	100	214
Dock labourers	50	132	93	81	100	172
Railwaymen	49	143	104	99	100	199
Printers' compositors	47	125	100	100	100	210
Cotton	59	177	109	93	100	247
Wool	61	193	115	92	100	218
Local Authorities:						
Labourers	—	—	98	92	100	212
Trams	—	—	92	90	100	192
Lorry drivers	—	—	98	93	100	179
Coalmining	69	204	95	80	100	368
Agriculture	48	133	81	89	100	314
Women:						
Boot-making	—	—	96	88	100	240
Confectionery	—	—	93	93	100	262
Tailoring	—	—	87	100	100	232
Shirtmaking	—	—	87	100	100	232
Tobacco	—	—	100	100	100	182

1932–33, and in the great increase after 1938. Details are shown in Table 3. For some occupations there was no reduction in rates between 1924 and 1933, though no doubt there was unemployment and short time. All occupations shared in the rise from 1933 to 1938 except compositors, whose basic rate was unchanged from 1924 till 1936 or 1937, tobacco, where the minimum rate appears to have had little relation to actual earnings, and the minimum rates for tailoring and shirt-making. The great increase in agriculture and in coalmining wages after 1938 have perhaps an undue influence on the average as given in Table 3 on the 1924 system of weights.

Unskilled labour gained relatively to skilled in both war periods, largely because flat-rate increments were arranged instead of percentage changes. Where the data allow definite comparisons, we have:

London Building	1914	1921	1924	1933	1938	1952
Labourer's wage as percentage of Bricklayer's	75	89	75	75	75	87
Engineering. Main centres. Labourer's wage as percentage of Fitter's	58	71	70	70	74	86

Wages and Earnings

There have been general official enquiries into earnings in 1886, 1906, 1924, 1931, 1935, 1938 and yearly or half-yearly since 1940. There is little evidence in the inter-war period that the movements of average wage-rates differed from those of earnings except for short-time hours in periods of depression; but during both wars average earnings increased more rapidly than rates. The salient statistics for 1938 to 1951 are given in Table 4; they relate to manufacturing industries, only excluding coal mining, agriculture and railways. The series for "All" is affected by the

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TABLE 4

Principal Industries

		Average Weekly Earnings			*Wage† Rates*	*Weekly Hours Worked Men*
		Men, 21 and Over	*Women, 18 and Over*	*All**		
1938	October . . .	100	100	100	100	47·7
1940	July	129	120	130	112	—
1941	July	144	135	142	118	—
1942	July	161	167	160	124	—
1943	July	176	191	176	130	52·9
1944	July	180	198	182	135	51·2
1945	July	176	194	180	143	49·7
1946	October . . .	175	201	190	170	47·7
1947	O tober . . .	186	214	203	173	46·2
1948	October . . .	200	229	220	175	46·5
1949	October . . .	201	242	229	178	46·6
1950	October . . .	218	254	240	178	47·5
1951	October . . .	241	277	265	194	47·6

* Including youths and girls.
† Estimated average for the same group of industries.

changing relative numbers of men, women, boys and girls, and also by the ages of withdrawal for compulsory services. In spite of the reduction of hours and the introduction in some industries of the 5-day week in 1945, the average hours worked by men is estimated as the same in 1951 as in 1938. After the First World War there was a general reduction of 5 or 6 hours in the normal

TABLE 5

Index-numbers of Cost of Living, 1924–47, on basis July, 1914 = 100

	Year											
	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935
Jan. . . .	177	180	175	175	168	167	166	153	147	142	142	143
Feb. . . .	179	179	173	172	166	165	164	152	147	141	141	142
Mar. . . .	178	179	172	171	164	166	161	150	146	139	140	141
April . . .	173	175	168	165	164	162	157	147	144	137	139	139
May . . .	171	173	167	164	164	161	155	147	143	136	137	139
June . . .	169	172	168	163	165	160	154	145	142	136	138	140
July . . .	170	173	170	166	165	161	155	147	143	138	141	143
Aug. . . .	171	173	170	164	165	163	157	145	141	139	142	143
Sept. . . .	172	174	172	165	165	164	157	145	141	141	143	143
Oct. . . .	176	176	174	167	166	165	156	145	143	141	143	145
Nov. . . .	180	176	179	169	167	167	157	146	143	143	144	147
Dec. . . .	181	177	179	169	168	167	155	148	143	143	144	147
Average . .	175	176	172	167	166	164	158	147½	144	140	141	143

	Year											
	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
Jan. . . .	147	151	159	155	176	196	200	199	199	202	203	204
Feb. . . .	147	151	157	155	177	197	200	199	200	202	203	203
Mar. . . .	146	151	156	153	179	197	200	199	200	202	203	204
April . . .	144	151	154	153	178	198	199	198	200	202	203	203
May . . .	144	152	156	153	180	200	200	199	200	203	204	203
June . . .	144	152	155	153	181	200	199	198	200	204	203	203
July . . .	146	155	159	156	187	199	200	200	201	207	205	—
Aug. . . .	146	155	156	155	185	199	201	199	202	205	205	—
Sept. . . .	147	155	156	155	187	199	200	198	202	203	203	—
Oct. . . .	148	158	155	165	189	199	200	199	201	203	203	—
Nov. . . .	151	160	156	169	192	201	200	199	201	203	203	—
Dec. . . .	151	160	156	173	195	201	200	199	201	203	204	—
Average . .	147	154	156	158	184	199	200	199	201	203	203	—

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working week, but the effect on earnings is obscure (4). There is need of further analysis of the relation of normal hours, wage-rates and earnings, which is in any case outside the scope of this article.

Cost of Living and Retail Prices

1924–38.—The index of price changes, usually termed the Cost of Living Index, was established at the outset of the First World War and has been published with no change in weights or method from July, 1914, to June, 1947. It measures the movement of the cost of purchasing at each date a budget of goods, houseroom, etc., constituted in 1914. This budget was based on an enquiry in 1904 in which details of expenditure were collected from working-class households, each consisting of a married couple, usually with children at home. Slight changes were made to allow for known alterations in foods, and since the courses of prices and of wages were parallel and changes inconsiderable in the ten years, this 1914 budget represents with fair accuracy the expenditure and standard of living of an ordinary working-class family at that date. The original figures (as percentages of the 1914 level, not percentage increases) are given in Table 5 for 1924 to 1947, and exhibited in the Chart.

1914–24.—During the war period 1914–19 the index was unrealistic, since in a time of scarcity and rationing the goods included could not in all cases be purchased, and some alternative measures were suggested (5). The originals (see *Ministry of Labour Gazette*, 1925, p. 8) for July in each year, which are used for the Chart are:

Index of Cost of Living

July,		*July*	
1914	100	1919	205–210
1915	125	1920	252
1916	145–150	1921	219
1917	180	1922	184
1918	200–205	1923	196

1914 *and* 1938.—No further general collection of budgets was made till 1937–38. It was found that little change would have been made in the index number in the period 1914–1938, if the new collection had been introduced for weighting.

	1914	1937–38	
		Old Basis	*New Basis*
Food	100	142	144
All items	100	157	162

This estimate (made by Mr. Nicholson (6)) is of course approximate, since some of the items in 1937–38 could not be priced backwards to 1914.

1938–47.—With the great rise of prices that began in 1939 the old Cost of Living index changed its relevance, and implicitly applied to only part of ordinary working-class or other expenditure. By the use and adjustment of subsidies the index was deliberately kept nearly stationary from 1941 to 1947, while less essential goods were subject to purchase tax. Professor R. G. D. Allen who was a member of the Cost of Living Advisory Committee, has estimated the change in price of the 1937–38 budgets, and compared them with the old Cost of Living Index as follows (6):

TABLE 6

	Index Numbers 1938–47									
	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
Former Cost of Living basis	100	102	119	128	129	128	130	131	131	131
1937–8 budgets	100	103	120	132	142	146	149	150	152	160

The entries in the second line for 1942 and 1947 are marked A and B in the graph. Mr. D. Seers obtained very nearly the same result for 1947 working on a different basis (7).

It is natural to wish to compare the movements of wages and of prices. The common method of dividing the former by the latter and terming the result "real wages" is, except for short periods,

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open to many objections, and at least needs special analysis and criticism, which is out of place here.

An alternative method is by subtraction rather than by division. Regard the 1914 budget as a minimum which provides prime necessaries and adequate calories (8), but little margin for anything that can be termed luxuries. Though it was an improvement on earlier decades, it would now be regarded as a bare minimum, and it does not differ greatly in food from the rationed commodities of *circa* 1943. In 1938 it was found that there was a considerable margin after the earlier budget contents were subtracted, a margin spent on new commodities or an increase on "semi-luxuries" or insurance. At that date about 78 per cent. of expenditure was needed to meet the 1914 budget, and 22 per cent. was free (except for compulsory insurance). At other dates this margin was approximately 8 per cent. in 1924, 41 per cent. in 1947, and about 37 per cent. (possibly more) in 1952.

1947–52.—After June, 1947, no official statistics were published on the bass of the 1914 budget. The old Cost of Living Index was replaced by an "Interim Index of Retail Prices" primarily based on the 1937–38 budgets.† This Index shows an increase of 35 per cent. from June, 1947, to May, 1952. In the Chart the line from D to E shows the movement of the Index, equated at D (June, 1947) to the old Cost of Living Index. The figures are given in Table 6.

In the Chart the point C is that reached by applying the 35 per cent. to Professor Allen's estimate (B) for 1947 described above. (The straight line DE is parallel to BC.)

The uncertainty of the rather hypothetical meaning of any estimate of the term "Cost of Living" in recent years is not of practical importance, for the claims for wage increases since 1947 have been to a large extent supported by the new Retail Price Index, and the earlier index tends to be of only historical interest.

TABLE 7

Index of Retail Prices, 1947–52

	1947	1948	1949	1950	1951	1952
Jan.	—	104	109	113	117	132
Feb.	—	106	109	113	118	133
Mar.	—	106	109	113	119	133
April	—	108	109	114	121	135
May	—	108	111	114	125	135
June	100	110	111	114	125	138
July	101	108	111	114	126	138
Aug.	100	108	112	113	127	137
Sept.	101	108	112	114	128	—
Oct.	101	108	112	115	129	—
Nov.	103	109	112	116	129	—
Dec.	104	109	113	116	130	—

The above multiplied by 2·03 to link on to the Cost of Living Index in June, 1947.

	Basis July, 1914 = 100					
	1947	1948	1949	1950	1951	1952
June	203	223	225	231	254	274 (May)
Dec.	211	221	229	235	264	—

	On Basis Average 1938 = 100					
	1947	1948	1949	1950	1951	1952
June	130	143	144	148	162	175 (May)
Dec.	135	142	147	152	169	—

† The new index does not cover exactly the same sector of the population as the old one, since the 1937–38 budgets included all persons insured against unemployment—that is, it included a considerable proportion of salaried employees. Mr. Seers (7) estimated in 1948 that in the period 1938–47 prices for the "salaried lower middle class" had risen 68 per cent., while those for the "working class" had risen 61½ per cent.

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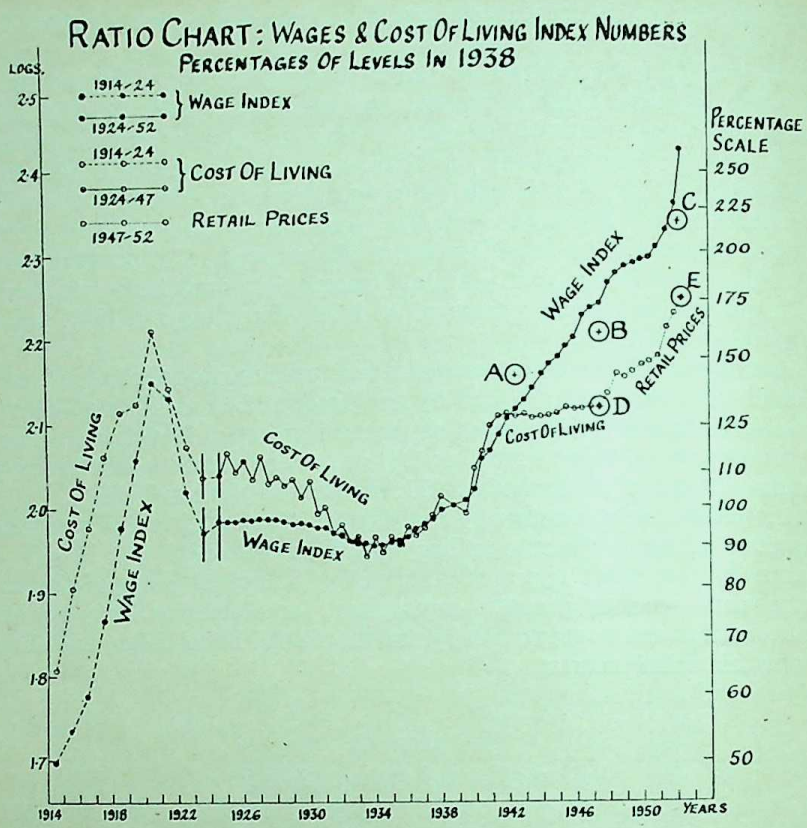

A and B are from Table 6, second line, and show the increase in the Cost of Living from 1938 weighted the 1937–8 budgets. C shows the further rise 1947–52 indicated in Table 7.

D is the point reached by the old Cost of Living Index in June 1947, and E is the point reached as in the last section of Table 7.

References

(1) See also BOWLEY, A. L. (1947), "Wages, earnings and hours of work", *Bull. Lond. Cam. Econ. Service Spec. Memor.* 50.
(2) —— (1921), *Prices and Wages in the United Kingdom* 1914–20. London: Clarendon Press.
(3) —— (1929), "A new index-number of wages", *Bull. Lond. Camb. Econ. Service*, Spec. Memor. 28.
(4) See Ref. (1) above, pp. 10–11.
(5) See Ref. (2) above, pp. 71–3.
(6) ALLEN, R. G. D. (1948), *Bull. Lond. Camb. Econ. Service*, **26**, 18.
(7) SEERS, D. (1948), *Bull. Oxford Univ. Inst. Statist.*, **10**, 143,257.
(8) The detail of the Index is described in the *Labour Gazette*, March, 1920, pp. 118–120. A summary of the 1914 Budgets is given in *An Elementary Manual of Statistics* by A. L. Bowley, 6th ed., p. 217. The caloric values of similar budgets are estimated in *Economica*, vol. 1, pp. 226–30, in an article by Miss W. A. Mackenzie, *Changes in the Standard of Living in the United Kingdom*, 1860–1914.

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An Exercise in Errors*

By A. D. Roy

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I

Economic statisticians constantly derive new and exciting information from the rather drab and non-committal figures that are issued officially in a steadily expanding stream. These new estimates, which the economic statisticians obtain after so much research and painstaking calculation, are no doubt "best" estimates in some peculiar sense which it would be rather hard to define. Some "best" estimates are better than others, but few economic statisticians seem to make any serious attempt to determine how good their "best" estimates really are.

It is hard to believe that any figure quoted without either an overt or implied indication of its reliability is worth all the trouble taken in obtaining it. What is particularly worrying is the use of residual statistics obtained from differencing two estimates of doubtful reliability without any indication of the enormous error which is almost certainly involved.

This seems to be a really serious fault, and blame cannot be exclusively attached to the government statisticians for failing to indicate the reliability of the figures which they publish. It is perfectly possible, while continuing to press for the improvement of official statistics, to make some sort of plausible assumption about the reliability of the existing statistics. Then at least some idea will be conveyed of the sensitivity of the derived estimates with respect to the possible errors in the basic statistics.

It is to be hoped that official statisticians may soon follow the example of Dr. R. C. Desai (1948), of Miss A. L. Chapman (in press) and of the National Income Statisticians of the Irish Republic in attempting to give an indication of the reliability of their estimates. However, I do not wish to pursue this theme here, but instead to demonstrate that the users of official statistics are under an obligation to allocate reasonable estimates of error to the basic statistics, and then to obtain possible margins of errors for the statistics they derive. These errors should be published with the derived figures. If it happens, as well it may, that the new statistics are shown to be subject to errors of alarming size, nothing but good will result. The public will be prevented from taking the new figures very seriously, while the statistician will realize that there are more profitable outlets for his energies.

In this paper I am attempting to achieve two ends. I wish to illustrate, using a practical example, the technique and the difficulties of the user-statistician in estimating margins of error. Also the results obtained may be regarded as useful in themselves because of the light that they shed on the reliability of some much publicized derived statistics.

With these aims in view the interesting estimates made by Mr. Dudley Seers of the movements in the middle-class cost of living will be considered. The weights for Mr. Seers's index are essentially obtained by taking the differences between two series of estimates, i.e., those for working-class expenditure and for all consumers' expenditure in 1938, both of which are conceivably subject to considerable error. The reader is referred to Mr. Seers's work for the precise definition of the working class, which broadly corresponds with that used in the Ministry of Labour budget inquiry of 1937–8. Here the concern is not with alternative definitions, but with the errors that may exist in the estimates on the existing definitions. Middle class, however, here means everyone who is not working class in Mr. Seers's sense.

I will consider first of all what errors may exist in the basic statistics used. Then I will examine what such errors may be deemed to imply, i.e., is it reasonable to conceive of the original statistics

* My acknowledgments are due to Professor C. F. Carter and Dr. A. R. Prest for their helpful comments and to the computing staff of the Department of Applied Economics, Cambridge. Needless to say, I am solely responsible for all the errors committed.

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as having sampling distributions or not? Having answered such questions I shall determine, on suitable assumptions, what errors there are likely to be in Mr. Seers's weights and what future error these will cause in the index itself.

In order to retain a reasonable degree of simplicity, it will be assumed throughout that the errors in Mr. Seers's price data and the price estimates he derives from them are negligible. The existence of substantial errors of this kind would not necessarily increase the error in the index but might reduce it, since they might be correlated appropriately with the estimates of the weights.

II

On the basis of slight unofficial experience in the estimation of consumers' expenditure and some consultation of the published estimates of error, it is not unreasonable to attribute the following errors to the official estimates of consumers' expenditure in 1938. The errors given here must be regarded as little more than guesses. The purpose is, however, simply to take account of the fact that they exist and any guess is therefore better than none.

TABLE 1

Assumed Errors in Consumers' Expenditure in the United Kingdom, 1938
(£ *million*)

Item	*Official Estimates**	*Error (plus or minus)*	
		Percentage	*Absolute*
Food	1,305	*5*	65
Alcoholic drink	285	*5* (beer) *10* (other)	19
Tobacco	177	*5*	9
Rent, rates and water charges	491	*10*	49
Fuel and light	197	*10*	20
Durable household goods	234	*20*	47
Other household goods	54	*10*	5
Clothing	446	*10*	45
Books, newspapers and magazines	64	*15*	10
Motoring and travel	290	*15*	44
Communication services	29	*20*	6
Entertainments	64	*30*	8
Domestic service	121	*30*	36
Other services	362	*35*	127
Other goods	177	*35*	62
Income in kind of the armed forces	17	*10*	2
Personal expenditure abroad	34	*15*	5
Total	4,347		

* From Cmd. 7933. Since the following calculations were done "Other Services" has been revised to £393 million (Cmd. 8203).

In case it may be thought that these guesses at errors are excessively pessimistic, it should be remembered that the problem of estimation often lies less in obtaining the total purchases of a certain commodity than in the difficulty of allocating such purchases between enterprises and final consumers.

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1952]

As far as working-class expenditure is concerned I have assumed that the average expenditure for a working-class family in 1938 on various items may involve the following errors:

TABLE 2

Assumed Errors for Expenditure Items of Average Working-Class Family in the United Kingdom, 1938

Item	*Error (plus or minus) (per cent.)*
Food	$2\frac{1}{2}$
Rents, rates and water charges	
Fuel and light	
Durable household goods	
Other household goods	
Clothing	
Alcoholic drink	5
Tobacco	
Books, newspapers and magazines	
Motoring and travel	
Communication services	
Entertainments	
Domestic service	
Other services	
Other goods	

Not much of this error is ascribable to sampling in the inquiry of 1937–8. Rather this error arises from the fact that the typical family in the Ministry of Labour's inquiry may not be typical of the working class on Mr. Seers's definition. The estimates of error given above are probably conservative.

Some guess about the size of one further source of error must be made. Mr. Seers estimated that working-class expenditure in 1938 (less income in kind of the armed forces) amounted to £2,347 million. I will assume that this figure might be out by as much as 5 per cent. either way.

Having accepted the possibility of error and having somewhat arbitrarily assigned various sizes of error to different items, what is the real meaning of a statement that there is an error in the official estimate of food expenditure in 1938 of plus or minus 10 per cent., i.e., £65 million? In what follows the implications of two possible interpretations are pursued, but there are no doubt others which may conceivably be of greater significance.

Suppose first that the statement about the error in the food estimate really means that there is only a chance of one in twenty that the expenditure on food in 1938 lies outside the limits of the range £1,240 to 1,370 million. Further let the comforting assumption be made that the error on any particular occasion will be normally distributed and independent of the error in any other expenditure item, thus there is a chance of having compensating errors on a fair proportion of occasions. Independence is assumed in default of any precise knowledge about the intercorrelations of the various errors. If, however, any particular assumptions about such intercorrelations appeared reasonable, there would be no difficulty in taking account of them.

The assumptions so far made have certain implications. If this is what is meant by "error", the error in the estimate of total consumers' expenditure in 1938 can be calculated and is of the order of $8\frac{1}{2}$ per cent., i.e., I can assert with 95 per cent. confidence that consumers' expenditure lies between £4,160 and 4,534 million. It does not seem, therefore, that the original errors assumed in the component items of consumers' expenditure imply any excessive error in the total.

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By using a result due to Dr. R. C. Geary (1930*) certain statements can now be made about the error in the estimates of the proportion of total expenditure which the working class devoted to various kinds of consumption in 1938.

TABLE 3

Working-Class Expenditure in the United Kingdom, 1938; Estimated Proportionate Distribution and the Errors Therein

Item	*Proportion of Total Expenditure (per cent.)*	*Absolute Error (plus or minus) in Estimated Proportion (95 per cent. Fiducial Limits) (per cent.)*
Food	40·1	±0·7
Alcoholic drink	6·9	±0·3
Tobacco	5·0	±0·2
Rents, rates and water charges	12·4	±0·3
Fuel and light	6·1	±0·2
Durable household goods	4·9	±0·1
Other household goods	1·8	—
Clothing	8·7	±0·2
Books, newspapers and magazines	1·2	±0·1
Motoring and travel	2·9	±0·1
Communication services	0·5	—
Entertainment	1·8	±0·1
Domestic service	0·2	—
Other service	5·9	±0·3
Other goods	1·6	±0·1
	100·0	

As might be expected, these errors are of very modest proportions. The errors given above, however, are not now independent of one another. Middle-class expenditure on the various items is obtained by multiplying the proportions given in the first column of the above table by £2,347 million and subtracting the figures so obtained from the official estimates of consumers' expenditure. Making use of Dr. Geary's work yet again it is possible to calculate errors in the proportionate distribution of estimated middle-class expenditure, which this process of differencing yields (Table 4).

Thus this procedure produces estimates of middle-class weights for a price index number which are subject to very substantial errors indeed in some cases, e.g., expenditure on Other goods and on Other services. Again it must be emphasized that the errors given are not independent of each other.

Despite these large errors in the estimates of the middle-class proportionate expenditure on various broad categories of goods, it does not necessarily follow that any very great error will be involved in the price index, which is calculated therefrom. To discover this error attention will be confined for the moment, to the year 1947, as it was for this year alone that Mr. Seers was able to estimate the price relatives (with 1938 = 100) for the working-class cost of living (Table 5).

* See also Appendix to this article.

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TABLE 4

Middle-Class Expenditure in the United Kingdom, 1938; Estimated Proportionate Distribution and the Errors Therein

Item	*Proportion of Total Expenditure (per cent.)*	*Absolute Error (plus or minus) in Estimated Proportion (95 per cent. Fiducial Limits) (per cent.)*
Food	18·3	±3·6
Alcoholic drink	6·3	±1·1
Tobacco	3·0	±0·6
Rents, rates and water charges	10·1	±2·5
Fuel and light	2·7	±1·0
Household durable goods	6·0	±2·3
Other household goods	0·7	±0·3
Clothing	12·3	±2·3
Books, newspapers and magazines	1·8	±0·5
Motoring and travel	11·3	±2·3
Communication services	0·9	±0·3
Entertainment	1·2	±0·4
Domestic service	5·9	±1·8
Other services	11·0	±5·8
Other goods	7·0	±3·0
Expenditure abroad	1·7	±0·3
	100·0	

Note.—Figures do not add exactly to 100 per cent. because of rounding errors.

TABLE 5

1947 *Price Relatives* (1938 = 100) *for Working-Class and Consumers' Expenditure in the United Kingdom: Mr. Seers's Price Relatives*

Item	*Working Class*	*Consumers' Expenditure*
Food	137	151
Alcoholic drink	253	251
Tobacco	339	338
Rents, rates and water charges	111	111
Fuel and light	150	149
Durable household goods	206	223
Other household goods	153	153
Clothing	174	191
Books, newspapers and magazines	119	119
Motoring and travel	135	147
Communication services	135	135
Entertainment	178	171
Domestic service	213	213
Other services	144	144
Other goods	185	224
Income in kind of the armed forces	159	159
Expenditure abroad	—	255

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Using the same assumptions as before about the extent and the interpretation of the errors involved, the errors implied in the three index numbers in which we are interested can be calculated.

TABLE 6

Index Number	*Estimated Level in* 1947 (1938 = 100)	*Absolute Error (plus or minus) (95 per cent. Fiducial Limits)*
Working-class cost of living . . .	161·3	±0·6
Consumers' price index	173·0	±1·6
Middle-class cost of living . . .	187·1	±4·4

Thus although the error in the middle-class cost of living is considerably greater than those of the other two indices, it is really of a quite modest size.

Assuming that for the years 1946, 1948 and 1949 the absolute error in the working-class cost of living was the same proportion of the estimated index for the year as in 1947, the errors* in the middle-class cost of living for these years can be obtained as before.†

TABLE 7

Estimates and Errors for Index Numbers, 1946–9
(95% *Fiducial Limits*)
(1938 = 100)

Index Number	1946	1947
Working-class cost of living . . .	151·5 (±0·6)	161·3 (±0·6)
Consumers' price index	162·4 (±1·5)	173·0 (±1·6)
Middle-class cost of living	175·6 (±4·2)	187·1 (±4·4)
	1948	1949
Working-class cost of living . . .	175·5 (±0·7)	181·5 (±0·7)
Consumers' price index	184·4 (±1·7)	190·6 (±1·8)
Middle-class cost of living	195·2 (±4·4)	201·7 (±4·6)

I have thus shown that what may be termed the "probabilistic" approach implies fairly large errors in the estimated distribution of middle-class expenditure but not very serious errors in the estimated level of the middle-class cost of living. It must be understood however that Mr. Seers's definitions are accepted for our purpose without any reservation whatsoever.

III

Many people will have serious doubts about the justification for assuming any particular probability distribution for the errors in the estimates made by economic statisticians, either official or otherwise. These doubts seem inherently reasonable, and I will now try to see what will happen when any such assumption is dispensed with.

Suppose that if the error in the estimate of consumers' expenditure on food is £65 million, this means that the "true" figure lies between £1,240 million and £1,370 million, and that any figure within this range cannot be assumed to have any specific probability. This interpretation

* These errors are those in the absolute size of the various indices. Owing to the serial correlation of the price series the indices for succeeding years are not statistically independent, and thus the errors in the year-to-year movements of the indices will be much smaller.

† When this paper was first written, the information was only available up to 1949. In view of the revisions that have taken place in the interim, no useful purpose would be served by carrying out further calculations for 1950 and 1951.

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of the error assumptions naturally leads* to rather more pessimistic conclusions about the reliability of our various estimates.

Table 3 must now be replaced by the following table:

TABLE 8

Working-Class Expenditure in the United Kingdom, 1938; *Estimated Proportionate Distribution and the Errors Therein*

Item	*Proportion of Total Expenditure (per cent.)*	*Absolute Error**	
		plus (per cent.)	*minus (per cent.)*
Food	40·1	+1·5	−1·4
Alcoholic drink	6·9	+0·5	−0·5
Tobacco	5·0	+0·4	−0·4
Rents, rates and water charges	12·4	+0·7	−0·6
Fuel and light	6·1	+0·3	−0·3
Durable household goods	4·9	+0·3	−0·3
Other household goods	1·8	+0·1	−0·1
Clothing	8·7	+0·5	−0·4
Books, newspapers and magazines	1·2	+0·1	−0·1
Motoring and travel	2·9	+0·2	−0·2
Communication services	0·5	+0·1	−0·0
Entertainment	1·8	+0·2	−0·2
Domestic service	0·2	+0·2	−0·2
Other services	5·9	+6·3	−5·5
Other goods	1·6	+1·8	−1·5
	100·0		

* The errors in the proportions are now asymmetrical. For instance if $x_1 = 10 \pm 5$ and $x_2 = 3 \pm 1$ it can easily be verified that $\frac{x_2}{x_1 + x_2}$ is equal to $23 \begin{matrix} +21 \\ -11 \end{matrix}$ per cent.

Once more the errors in the different items of expenditure are not independent of one another. On this new interpretation the errors imputed to the official estimates of the components of consumers' expenditure imply that there is a maximum possible error of just under 13 per cent. in total consumers' expenditure. An error as large as this may seem excessive but, as will be shown later, the greatest errors in the middle-class cost of living index do not occur when the error in total consumers' expenditure is anything like as large as this.

Similarly although the estimates of the greatest possible errors in the proportions of middle-class expenditure may appear improbably large in some instances, because of the assumption that the error in each item of consumers' expenditure is independent of the errors in the other items, the maximum errors in the middle-class cost of living occur when the proportions are not at their extreme values.†

It seems therefore that the errors given in the next table should be regarded as outer limits, which may be proved to be excessive or not on the basis of further internal evidence. For instance the downward error in the proportionate expenditure on fuel is certainly too large, and so is the similar error for other household goods. This illustrates the extreme difficulty of constructing a plausible scheme for the errors in various statistics which is consistent with the other information available.

* See Appendix at end of this article.

† This follows because the extreme errors in the middle-class index arise when there is quite a small error in total consumers' expenditure, i.e., when the component errors are related in a particular way; but see Table 12, para. 1 of page 515 and Part II of the Appendix.

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TABLE 9

Middle-Class Expenditure in the United Kingdom, 1938; Estimated Proportionate Distribution and the Errors Therein

Item	*Proportion of Total Expenditure (per cent.)*	*Absolute Error*	
		plus (per cent.)	*minus (per cent.)*
Food	18·3	+11·7	−9·0
Alcoholic drink	6·3	+4·4	−2·8
Tobacco	3·0	+2·4	−1·5
Rents, rates and water charges	10·1	+7·4	−5·0
Fuel and light	2·7	+2·7	−2·0
Household durable goods	6·0	+5·7	−3·5
Other household goods	0·7	+0·7	−0·6
Clothing	12·3	+8·1	−4·8
Books, newspapers and magazines	1·8	+1·6	−0·9
Motoring and travel	11·3	+7·7	−4·4
Communication services	0·9	+0·9	−0·5
Entertainment	1·2	+1·2	−0·8
Domestic service	5·9	+5·0	−2·8
Other services	11·0	+11·5	−7·4
Other goods	7·0	+6·9	−4·0
Expenditure abroad	1·7	+1·6	−0·7
	100·0		

Note.—Figures do not add exactly to 100 per cent. because of rounding errors.

It can now be seen that the error in every estimated proportion is very large, and that on the evidence it is possible to be certain of very little. In particular all that can be said about the proportions of its total expenditure which the middle class devoted to Motoring and travel and to Other services, is that for the former it lies between 7 per cent. and 19 per cent. and for the latter between 4 per cent. and 23 per cent. These are not helpful conclusions. Guesses made without all these extensive calculations would hardly give less reliable estimates. In fact, once these particular assumptions about the errors in the basic statistics are made, the past labours are found to have borne no fruit at all. Common sense and rules of thumb would be less expensive in time and trouble.

If now the possible extreme values of the three index numbers, which the present interpretation of the errors implies, are calculated, the following results for 1947 are obtained:

TABLE 10

Index Number	*Estimated Level in 1947 (1938 = 100)*	*Absolute Error*	
		plus	*minus*
Working-class cost of living	161·3	+1·5	−1·4
Consumers' price index	173·0	+5·1	−4·9
Middle-class cost of living	187·1	+16·7	−13·6

On the further assumption that the absolute error in the working-class cost of living bore the same proportion to the level of the index in 1946, 1948 and 1949 as in 1947, the figures in the next table can be derived.

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TABLE 11

Estimates and Errors for Index Numbers 1946–9
(1938 = 100)

Index Number	1946	1947
Working-class cost of living	151·5 +1·4 −1·3	161·3 +1·5 −1·4
Consumers' price index	162·4 +4·8 −4·6	173·0 +5·1 −4·9
Middle-class cost of living	175·6 +15·8 −12·8	187·1 +16·7 −13·6
	1948	1949
Working-class cost of living	175·5 +1·6 −1·5	181·5 +1·7 −1·6
Consumers' price index	184·4 +5·5 −5·2	190·6 +5·6 −5·4
Middle-class cost of living	195·2 +17·2 −13·9	201·7 +18·6 −14·3

It is abundantly clear that the middle-class cost of living index derived by Mr. Seers is a very rough guide indeed on our present assumptions. It can be asserted that this index has risen more than the working-class cost of living to the extent of at least 7 points by 1949. An informed guess might have told almost as much.

TABLE 12

Distribution of Middle-Class Expenditure in 1938 *Required to Produce Extreme Errors in Middle-Class Index in* 1947

Item	*Upper Extreme Error* *Proportion of total expenditure (per cent.)*	*Lower Extreme Error* *Proportion of total expenditure (per cent.)*
Food	13·4	22·1
Alcoholic drink	8·2	4·7
Tobacco	4·0	2·3
Rents, rates and water charges	7·4	12·1
Fuel and light	1·4	3·7
Durable household goods	9·3	3·3
Other household goods	0·3	1·0
Clothing	16·2	9·1
Books, newspapers and magazines	1·3	2·1
Motoring and travel	9·9	12·3
Communication service	0·6	1·1
Entertainment	0·9	1·4
Domestic service	8·7	3·6
Other services	4·8	16·4
Other goods	11·5	3·5
Expenditure abroad	2·2	1·3
	100·0	100·0
Implied expenditure per head	£185–247	£233–311

Note.—Figures do not add exactly to 100 per cent. because of rounding errors.

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In order that the suspicious may not think that the large errors in the middle-class cost of living are the result of some highly improbable assumptions about the distribution of middle-class expenditure in 1938, it is worth while specifying what distribution would produce these extreme results.

Perhaps someone will be prepared to say that either or both of these distributions of expenditure are quite impossible. I do not know of any evidence which enables us to decide whether either distribution given above can be rejected as ridiculous. If such evidence were available it would not have been necessary for Mr. Seers to carry out his elaborate and lengthy calculations.

Some interest attaches to the *per capita* expenditure implied for both the middle and working class by the assumptions that lead to the upper and lower extreme values of the middle-class index. The following table is based upon the population estimates used by Mr. Seers, i.e., 7·1 to 9·5 million persons were assumed to be in the middle classes in 1938 while between 38·0 and 40·4 million were working class:

TABLE 13

Expenditure per Head of Working and Middle Class, 1938

Item	*Working Class* (£)	*Middle Class* (£)
Food	22–27	25–69
Alcoholic drink	4	10–20
Tobacco	3	5–10
Rent, rates and water charges	7–8	14–38
Fuel and light	3–4	3–12
Durable household goods	3	8–23
Other household goods	1·0–1·2	1–3
Clothing	5	21–40
Books, newspapers and magazines	0·7–0·8	2–7
Motoring and travel	2	18–38
Communication services	0·2–0·3	1–4
Entertainment	1	2–4
Domestic service	0·1	8–22
Other services	3–4	9–51
Other goods	1	8–28
Expenditure abroad	*nil*	3–6

Certain figures here are more probable than others, but since the middle class includes here everyone except the working class, it would be rash to insist that any of the upper limits of *per capita* expenditure are definitely too large.

Despite these enormous variations in the possible patterns of middle class expenditure, which result from the assumptions made, the component errors are related in such a way that we are postulating an error of only 2·6 per cent. in the total of consumers' expenditure, i.e., it lies in the range £4,234–£4,460 million. This would seem to be a very modest margin of error indeed.

IV

The moral of this little exercise should now be clear. The best estimates that can be made under given circumstances are only meaningful if it can be stated how good these estimates are. To do this, some knowledge of the errors in the basic statistics used is required, and if possible some detailed knowledge of how one error may be related to another. Account must then be taken of the effect on these errors of the various arithmetical manipulations which are carried out. Differencing clearly magnifies small proportionate errors, sometimes to a positively alarming extent. The calculation of an index number on the other hand reduces them to more

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modest proportions because of the high correlation that exists between the numerator and denominator of such a ratio.

A great deal of work requires to be done on the possible interpretation of the errors that occur in economic statistics. Is it reasonable to assume that they have some sort of probability distribution, or must we abandon this comforting notion more or less completely? This is certainly a question that cannot continue to be evaded much longer.

All economic statisticians have a clear responsibility for showing how sensitive their multitude of derived statistics are to plausible changes in their basic assumptions. Until difficulties about the proper interpretation of errors have been resolved, the least they can do is to give upper and lower limits to every estimate published. To ignore the possibility of error, because of doubt of precisely the right thing to do, is to mislead still further an unfortunately gullible public.

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APPENDIX ON THE METHOD OF CALCULATING ERRORS

I. *Probabilistic Approach*

Dr. Geary has shown (1930) that if x_1 and x_2 are two normally distributed variates with means m_1, m_2, variances σ_1^2, σ_2^2 and correlation r, and if $y = \dfrac{x_1}{x_2}$, then the function

$$\frac{m_2 y - m_1}{\sqrt{\sigma_2^2 y^2 - 2r\sigma_1\sigma_2 y + \sigma_2^2}} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

is normally distributed with zero mean and unit variance, provided that x_2 is unlikely to assume negative values.

If, therefore, $m_1 + a_1$, $m_2 + a_2$ are the 95 per cent. fiducial limits of x_1, x_2*, then the 95 per cent. fiducial limits of y are given by

$$\frac{m_2 m_1 - r a_1 a_2 \pm \sqrt{m_2^2 a_1^2 + m_1^2 a_2^2 - 2m_1 m_2 r a_1 a_2 - a_1^2 a_2^2 (1 - r^2)}}{m_2^2 - a_2^2}, \quad . \quad . \quad (2)$$

where

$$a_1 = 2\sigma_1 \text{ and } a_2 = 2\sigma_2.$$

In the case of an index number

$$x_1 = \sum_1^n p_i w_i,$$

where p_i is the price of the ith good and w_i is its weight, and

$$x_2 = \sum_1^n w_i.$$

* The argument here is rather loose, as in fact we do not know m_1, m_2 but only estimates of x_1, x_2. However this does not affect the results.

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If the w_i's are normally and independently* distributed with means h_i and 95 per cent. fiducial limits $h_i \pm k_i$, then—

$$m_1 \pm a_1 \equiv \sum_1^n p_i h_i \pm \sqrt{\sum_1^n p_i^2 k_i^2}$$

$$m_2 \pm a_2 \equiv \sum_1^n h_i \pm \sqrt{\sum_1^n k_i^2}$$

$$r = \frac{\sum_1^n p_i k_i^2}{\sqrt{(\sum_1^n k_i^2)(\sum_1^n p_i^2 k_i^2)}}. \quad \ldots\ldots\ldots \quad (3)$$

These values can be substituted in the formula given at (2) above.

To calculate the error in a proportion such as $\frac{w_j}{\sum_1^n w_i}$, put

$$m_1 \pm a_1 \equiv h_j \pm k_j$$

$$m_2 \pm a_2 \equiv \sum_1^n h_i \pm \sqrt{\sum_1^n k_i^2}$$

$$r = \frac{k_j}{\sqrt{\sum_1^n k_i^2}} \quad \ldots\ldots\ldots \quad (4)$$

and formula (2) will again yield the desired result.

Where the weights w_i $(i = 1, 2, \ldots n)$ are obtained by differencing the problem is more complicated in detail but the same in essence.

II. *Non-probabilistic Approach*

A. When the idea of a probability distribution for the errors is discarded, the values w_i $(i_1 = 1, 2, \ldots n)$ of the weights are only known to lie between the limits $h_i \pm k_i$ $(i = 1, 2, \ldots n)$.

Then the limits between which the index number must lie are given by

$$\frac{\sum_1^\nu p_i(h_i + k_i) + \sum_{\nu+1}^n p_i(h_i - k_i)}{\sum_1^n h_i + \sum_1^\nu k_i - \sum_{\nu+1}^n k_i} \quad \ldots\ldots\ldots \quad (5)$$

and

$$\frac{\sum_1^\nu p_i(h_i - k_i) + \sum_{\nu+1}^n p_i(h_i + k_i)}{\sum_1^n h_i - \sum_1^\nu k_i + \sum_{\nu+1}^n k_i},$$

* The results can be suitably modified if we know the intercorrelations between the w's.

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where p_i $(i = 1, 2, \ldots \nu)$ is less than

$$\frac{\sum_1^n p_i h_i}{\sum_1^n h_i}^*$$

and p_i $(i = \nu + 1, \nu + 2, \ldots n)$ is greater than

$$\frac{\sum_1^n p_i h_i}{\sum_1^n h_i}^*.$$

When we wish to calculate the limits of error in a proportion, we find that the proportion $\frac{w_j}{\sum_1^n w_i}$ lies between the limits

$$\frac{h_j - k_j}{\sum_1^n (h_i + k_i) - 2k_j} \quad \text{and} \quad \frac{h_j + k_j}{\sum_1^n (h_i - k_i) + 2k_j}. \qquad (6)$$

B. In the more complicated case when an index is given by

$$I = \frac{\sum_1^n p_i w_i - W \frac{\sum_1^n p_i' w_i'}{\sum_1^n w_i'}}{\sum_1^n w_i - W},$$

where w_i lies between the limits $h_i \pm k_i$, w_i' between $h_i' \pm k_i'$ and W between $Y \pm Z$, then I lies between

$$\frac{\sum_1^\nu p_i(h_i + k_i) + \sum_{\nu+1}^n p_i(h_i - k_i) - (Y - Z) \frac{\sum_1^{\nu'} p_i'(h_i' - k_i') + \sum_{\nu'+1}^n p_i(h_i' + k_i')}{\sum_1^n h_i' - \sum_1^{\nu'} k_i' + \sum_{\nu'+1}^n k_i'}}{\sum_1^n h_i + \sum_1^\nu k_i - \sum_{\nu+1}^n k_i - (Y - Z)}$$

and

$$\frac{\sum_1^\nu p_i(h_i - k_i) + \sum_{\nu+1}^n p_i(h_i + k_i) - (Y + Z) \frac{\sum_1^{\nu'} p_i'(h_i' + k_i') + \sum_{\nu'+1}^n p_i'(h_i' - k_i')}{\sum_1^n h_i' + \sum_1^{\nu'} k_i' - \sum_{\nu'+1}^n k_i'}}{\sum_1^n h_i - \sum_1^\nu k_i + \sum_{\nu+1}^n k_i - (Y + Z)}$$

provided that $\frac{\sum_1^n p_i' h_i'}{\sum_1^n h_i'}$ is less than $\frac{\sum_1^n p_i h_i}{\sum_1^n h_i}$ (if this is not so, the sign of Z is reversed).

* As a first approximation.

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As before p_i $(i = 1, 2, \ldots \nu)$ is less than $\frac{\sum_1^n p_i h_i}{\sum_1^n h_i}$ and p_i $(i = \nu + 1, \nu + 2, \ldots n)$ is greater than $\frac{\sum_1^n p_i h_i}{\sum_1^n h_i}$.* Similarly p_i $(i = 1, 2, \ldots \nu')$ is less than $\frac{\sum_1^n p_i' h_i'}{\sum_1^n h_i'}$ and p_i' $(i = \nu' + 1, \nu' + 2, \ldots, n)$ is greater than $\frac{\sum_1^n p_i' h_i'}{\sum_1^n h_i'}$.*

* All these criteria are again first approximations.

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A Criterion of Efficiency in Local Administration

By K. S. Lomax

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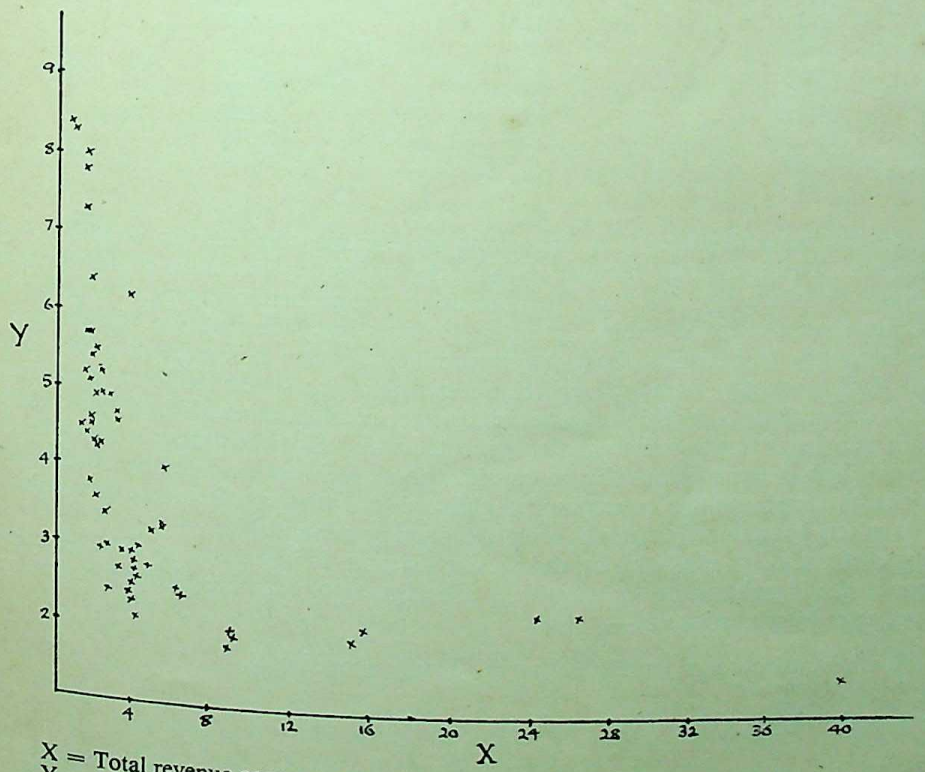
The efficiency of a local authority has usually been assessed on the basis of expenditure per head of the population. This is a most unsatisfactory procedure. Heavy expenditure may not imply extravagance or waste, but, on the contrary, may result from a high standard of service needing expenditure on a lavish scale. Then again, costs per head might be high as a consequence of exceptional needs.

An alternative approach would be to concentrate on the costs of what is the primary function of a local authority, namely, administration, and to investigate how administrative costs behave in relation to total expenditure. Authorities with varying requirements or standards of service provided would incur differing levels of expenditure. It would still be relevant to ask, however, whether an increase in total outlay calls for greater, equal, or lesser proportionate costs of administration. Total expenditure, here, should clearly be gross revenue account expenditure on rate-fund and trading services, since capital expenditure in any one year may be exceptional.

Definition and measurement of administrative costs present difficulties, but one solution would be to take as an indicator salaries in the Town Clerk's department. The Town Clerk and his staff are engaged predominantly on general administration, and the expenditure incurred should form an adequate basis for comparison of administrative costs. On the other hand, care should obviously be taken with such items as accommodation, stationery, etc., because of the possibility



X = Total revenue account expenditure on rate-fund and trading services in £ mn.
Y = Administrative costs per £1,000 of total expenditure, in £.

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of variation in practice between the different local authorities. It seems, in consequence, preferable to use salaries only in the Town Clerk's department as the appropriate variable. Ideally, of course, there is a case for taking salaries in all central departments concerned with general administration. However, City Engineers and Surveyors are also, to a considerable extent, providing a specific service direct to consumers. In the case of the Treasurer's department, the work of which is administrative in character and more purely akin to that of the Town Clerk, detailed scrutiny of County Borough accounts reveals considerable variation in accounting practice so that a consistent basis of comparison seems impossible of achievement.

In this paper, then, the relationship between salaries in the Town Clerk's department, referred to, for convenience, as costs of administration, and gross revenue account expenditure on rate fund and trading services is investigated for a sample of 58 county boroughs in England and Wales in the financial year 1947–48.*

The method adopted is, firstly, to calculate for each local authority, costs of administration, in the sense defined above, per £1,000 of total expenditure. The scatter diagram then shows the variation in this ratio exhibited by the 58 authorities.

There appears to be an unmistakable tendency for administrative costs to fall, relatively to total expenditure, as the size of the local authority increases. The behaviour is seen most vividly if the county boroughs are grouped according to size and arithmetic averages of administrative costs per £1,000 calculated for each group.

TABLE 1

Total Revenue Account Expenditure on Rate-fund and Trading Services (£ *million*)	*Number of County Boroughs*	*Mean Administrative Costs per* £1,000 *of Total Expenditure* (£)
0–1½	8	6·729
1½–2	10	5·101
2–3	12	3·870
3–4	9	3·475
4–6	9	2·978
6–10	5	2·100
15–16	2	2·020
24–27	2	2·310
39–40	1	1·487

The above figures being averages it is important to examine carefully the stability of the behaviour exhibited. This is essential because of the variation among individual county boroughs in each size-group. While every effort has been made to reduce heterogeneity to a minimum, some scatter about the trend is inevitable. In order to investigate the reality of the downward movement it is necessary to determine the most appropriate function fitting the data and to test its significance. Unfortunately, there is no criterion for deciding on the suitability of a particular form of equation except that, other things being equal, more confidence would be felt in a simple relationship such as a linear function than in a complicated one. However, there is only a limited number of curves which it seems reasonable to consider and which can be fitted by existing techniques. It is thus a simple matter conceptually, although burdensome from the viewpoint of computation, to select, by trial and error, the most satisfactory relationship.

With the type of variation exhibited by the scatter diagram it is natural to think of curves which are linear in the logarithms of the variables. The functions examined, then, are first and second order polynomial regressions of—

(*a*) Y (Administrative costs per £1,000) on X (Total expenditure),
(*b*) log Y on log X,
(*c*) log log Y on log log X.

* I am indebted to City and Borough Treasurers for granting access to their abstracts of accounts; to Mr. H. W. Cauthery of the Ministry of Local Government for providing figures of total expenditure; and to Miss D. I. Hewell of Manchester University for help in extracting data.

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The corresponding analyses of variance take the form:

TABLE 2

Source of Variation	*Variance* (a)	(b)	(c)	*Variance Ratio (F)* (a)	(b)	(c)	0·1 *per cent. Probability Level for F.*
Linear Regression Function	42·4596	1·33334	1·05517	22·5	129·3	137·4	12·1
Difference between first and second-order functions .	31·3335	0·12836	0·00411	16·6	12·4		12·1
Residual (error) . . .	1·8880	0·01032	0·00768				

The goodness of fit, as measured by the multiple correlation coefficient, is as follows:

TABLE 3

Regression	*1st Order*	*2nd Order*
(*a*) Y on X	0·489	0·645
(*b*) log Y on log X . . .	0·811	0·849
(*c*) log log Y on log log X .	0·844	0·846

It is apparent that (*c*) provides the most suitable basis for testing the behaviour of administrative costs. The linear regression function, in this case, is highly significant while higher order terms are completely unimportant, and yet the fit is inappreciably inferior to any other curve.

The linear regression of log log Y on log log X being highly significant, there is not the slightest doubt concerning the statistical validity of the decrease in administrative costs per £1,000 as total expenditure increases. Values given by the linear regression function for the groups listed in Table 1 are as follows:

X = Total revenue account expenditure on rate-fund and trading services.
Y = Administrative costs per £1,000 of total expenditure.

TABLE 4

Range of X (£ *million*)	*Frequency*	*Mean* X *Observed* (£ *million*)	*Mean* Y *Observed* (£)	Y *calculated from Regression Function* (£)
0–1½	8	1·228	6·729	6·347
1½–2	10	1·786	5·101	4·572
2–3	12	2·399	3·870	3·769
3–4	9	3·618	3·475	3·065
4–6	9	4·715	2·978	2·757
6–10	5	7·857	2·100	2·346
15–16	2	15·304	2·020	2·013
24–27	2	25·237	2·310	1·846
39–40	1	39·800	1·487	1·731

It is clear, then, that the variation among individual county boroughs at any one size level is not such as to vitiate the reality of the tendency for administrative costs to fall proportionately as the size of a local authority increases.

The consequences of this result in relation to local government structure need no emphasis. Large cities undoubtedly have certain disadvantages. The distribution of fresh food, the provision of adequate transport facilities, the development of citizenship and a feeling of community-interest among the inhabitants create problems which are probably more acute in the case of large cities than elsewhere. Nevertheless with regard to administrative costs the advantage certainly lies with the larger unit. Not always has this been realized. Support has been given to the view that above a certain size the economies to be derived from administrative division of labour cease to operate. Big authorities have been thought costly to govern. It may still be true that the needs of big cities call for heavy expenditure. The councils of places like Manchester, Liverpool and Birmingham perhaps tend to insist on a higher standard of service than in smaller towns. However, though this may be so, there appears now little reason to doubt the existence of increasing returns to scale of administration in the county boroughs of England and Wales.

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Employment in Shipbuilding and Ship-Repairing in Great Britain

By N. S. Ross
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The trend of employment in the shipbuilding and ship-repairing industry has in recent years given rise to some concern from time to time in Government, trade union and industrial circles. This was especially true of the years 1949 and 1950, when the unemployment rate in the industry was in the region of 6 per cent. compared with a general rate of less than 2 per cent., and it appeared to be the first major industry to display a noticeable tendency to depart from post-war standards of full employment. In December, 1951, the unemployment rate was still over 3 per cent. compared with an average rate of 1·8 per cent. for all industries. Concern has also been expressed about the increasing threat of foreign competition to an industry whose cost structure, like that of many other British industries, has become both rigid and high. High costs and the difficulty of obtaining orders for both new and repair work are referred to in the report of the annual general meeting of Cammel Laird & Company Ltd. on April 25th, 1950.

Mr. E. J. Hill, general secretary of the Boilermakers' Society, is also reported to have estimated that some 75,000 men would be surplus to the "normal" needs of the industry (*The Times*, December 5th, 1949). Although the immediate prospects of the industry improved as a result of the rearmament programme and the upward trend of freight rates associated with international political developments since mid-1950,* these factors may represent merely a further temporary interruption of a process of readjustment which began in the industry during the third decade of the present century.

In these circumstances an examination of the course of employment in recent years in this important industry may throw some light on its present position, and permit of some discussion of its structure and location in the light of more detailed information on employment during the war and in the post-war period. On the basis of an examination of the regional distribution of employment in the industry an attempt will be made not only to indicate the general trends, but also to consider the extent to which these may have been influenced by the division of the industry between new work and repairs and between naval work and merchant work. An attempt will also be made to show that the pre-eminence of the three principal centres of the industry, Scotland, and the Northern and North Western regions, considered as a group, is associated with its concentration on work of new construction, and therefore that any prolonged fall in world demand for new tonnage or its diversion to other sources of supply may modify considerably the distribution of the industry in Great Britain, since these principal regions do not appear to enjoy any marked advantage over the rest of the country in respect of repair work.

The shipbuilding and ship-repairing industry, as is well known, is highly concentrated in certain areas, being commonly cited as one of the classic examples of the influence of geographical factors on the localization of industry. But, if in this country the facts of geography have determined the overwhelming importance of the Clyde, the Tyne and the Mersey in this sphere, they have also necessitated, in an island community dependent upon international trade, the widespread development of various sections of the industry so that it occurs in varying degrees of importance in practically every administrative region. It is worth noting, however, that over the last twenty-five years something like 60 to 70 per cent. of all workers insured and employed in the industry in Great Britain were to be found in the regions bordering these northern rivers. Nevertheless, in spite of this, the available statistics of employment, after allowing for difficulties in the matter of comparability, suggest that this northern group was slowly declining in relative importance, a

* Freight rates, however, were in fact declining from October, 1951, and fell very rapidly in the first four months of 1952.

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trend which was obscured neither by the depression of the nineteen-thirties on the one hand nor by the impact of the second world war on the other. For the period before 1930 the percentages of the total insured persons employed in shipbuilding and ship-repairing in Great Britain located in these centres were as follows:*

Year	*Clyde*	*N.E. Coast*	*Merseyside and Barrow*	*Total*
	(%)	(%)	(%)	(%)
1923 . . .	22	21	19	62
1924 . . .	22	22	13	57
1927 . . .	26	24	13	63
1929 . . .	25	26	14	65
1930 . . .	24	26	13	63

Similar information relating to these precise areas is not available for subsequent years, but the following figures for the Scottish, Northern, and North Western Regions of the Ministry of Labour serve as a close approximation.†

Year	*Scotland*	*Northern Region**	*North Western Region*	*Total*
	(%)	(%)	(%)	(%)
1930 . . .	29	26	14	69
1931 . . .	23	19	17	59
1938 . . .	28	21	15	64
1939 . . .	27	22	14	63
1945 . . .	26	21	16	63
1947 . . .	25	22	16	63

* The percentages for 1930 and 1931 are based on statistics relating to the N.E. Coast Area taken from the Board of Trade Industrial Survey.

The period between the two wars was, of course, one of great contraction in the shipbuilding and ship-repairing industry, the number of persons aged 16 to 64 insured in the industry in Great Britain falling from 241,000 in 1924 to 184,000 in 1931 and to 166,000 in 1938. Changes in the number of insured persons employed were even more marked, falling from 175,000 in 1924 to 80,000 in 1931, recovering to 131,000 in 1938.‡ In general the principal centres of the industry suffered more heavily than the rest of the country during this period with the consequent changes

* Based on data from the Board of Trade Industrial Surveys of S.W. Scotland, N.E. Coast, and Merseyside.

† The difference in aggregate employment in the industry in the Survey areas and in the areas of the present Administrative Regions was probably of the order of five or six thousand only.

Except where otherwise indicated, figures relating to 1930–38 are based throughout on statistics from the *Ministry of Labour Gazette;* those relating to 1939–47 are based on tables relating to employment and unemployment in Great Britain, H.M.S.O., 1947 and 1948.

‡ The general trend in terms of output of merchant tonnage is illustrated by the following figures for the United Kingdom:

Year	*Gross Tonnage Launched* ('000)	*Five Years Moving Average of Gross Tonnage Launched* ('000)
1921 . . .	1,538	1,378
1924 . . .	1,440	968
1930 . . .	1,479	1,027
1931 . . .	502	951
1937 . . .	921	787
1938 . . .	1,030	856
1948 . . .	1,176	1,214

(Source: *Lloyd's Register of Shipping: Annual Summary of Shipbuilding.*)

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in their relative positions already noted. The varying regional trends in the years immediately before the war are illustrated in the following table of index numbers of insured persons employed in shipbuilding and ship-repairing in July of each year:

Region	1930	1931	1937	1938
Scotland	100	48	89	97
Northern	100	43	75	78
North Western	100	73	105	108
Scot. + N. + N.W.	100	51	87	92
Rest of Great Britain	100	81	118	120
Great Britain	100	60	97	100

War-time expansion carried the numbers insured in shipbuilding and ship-repairing in Great Britain from 173,000 in July, 1939 to 249,000 in July, 1945. By 1947 the numbers had fallen again to 217,000. Numbers employed rose from 142,000 in 1939 to 247,000 in 1945, falling to 209,000 by July, 1947. This war-time expansion, achieved by the use of extraordinary measures of direction and dilution of labour and by extended employment of women, restored the industry, in July, 1945, approximately to the dimensions it had enjoyed in 1924 when measured by the mid-year total of insured persons.* Nevertheless the employment statistics for the period 1939–47 provide evidence that the divergent regional trends of the previous decade have persisted. The following indices, based on the numbers of insured persons employed in July, 1939, convey the situation:

Region	1939	1945	1947
Scotland	100	172	138
Northern	100	169	150
North Western	100	186	163
Scot. + N. + N.W.	100	174	147
Rest of Great Britain	100	175	149
Wales	100	274	226
London and S. Eastern	100	168	170
Great Britain	100	174	147

Over the entire period under review, considerable changes occurred in the relative importance, as measured by employment, of the industry in the economy as a whole. The contraction of the industry after 1930 accelerated its relative decline, a movement which, although manifesting itself in every region, was especially marked in the principal shipbuilding regions, and, within this group, in the Northern Region and in Scotland. This was also broadly true of the reverse movement produced by the events of 1939 to 1945, as will be seen from the following table:

Percentage of Total Employed Insured Persons engaged in Shipbuilding and Ship-Repairing

Region	1930 (%)	1938 (%)	1939 (%)	1945 (%)	1947 (%)
Scotland	3·50	3·02	2·52	4·54	3·27
Northern	6·36	4·16	3·67	5·89	4·80
North Western	1·15	1·18	0·97	1·93	1·53
Scot. + N. + N.W.	2·80	2·34	2·00	3·61	2·77
Rest of Great Britain	0·56	0·58	0·52	1·00	0·75
Great Britain	1·27	1·12	0·96	1·83	1·38

* An account of the measures involved in dealing with the industry's manpower is given in the *Report of the Ministry of Labour and National Service*, 1939–46. Cmd. 7225, pp. 82–87.

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Although caution must be exercised in comparing the statistical series for 1930–38 with that for the later period, a comparative study of the above table presents a reasonably accurate picture of the national and regional trends. The North Western Region is sharply distinguished from the remaining two principal centres of the industry both by the much smaller percentage of employed-insured persons engaged in the industry and by the fact that, of the three regions, it alone shows higher percentages in 1947 as compared with 1930. In this respect it is comparable to the rest of Great Britain outside the main shipbuilding centres.

A study of the proportion of insured and insured employed persons in shipbuilding and ship-repairing in the various regions gives some indication that the industry is more highly concentrated in the three northern regions than in the rest of the country, and that, of these three, it is most highly concentrated in the Northern Region and least concentrated in the North West. These figures alone, however, are not sufficient to illustrate the degree of concentration, since account must be taken of the varying size of the Regions. This may be done by comparing the numbers actually employed with the numbers who would have been employed in the various regions if the percentage for the country as a whole had prevailed in each region or, in other words, if the industry had been uniformly distributed throughout Great Britain.* In the following table 100 has been taken to represent the numbers which would have occurred in each area on the basis of a uniform distribution of the industry in Great Britain and the appropriate index numbers have been calculated:

Region	1930	1939	1945	1947
Scotland	274	263	248	237
Northern	513	383	322	348
North Western	91	101	105	111
Scot. + N. + N.W. . . .	221	208	197	201
Rest of Great Britain . . .	44	54	55	54

The general trend in the three principal regions between 1930 and 1947 was towards a reduced degree of concentration in shipbuilding and ship-repairing, although here again, within the group, the North Western Region shows a marked divergence and provides a pattern of changes much more akin to that which emerges for the industry in the rest of Great Britain. The effect of the war-time expansion of the industry outside the principal centres is seen in the fall of the index in 1945 as compared with 1939 for the principal centres taken together and for Scotland and the Northern Region in particular. Despite their limitations, the figures for 1947 suggest that with the post-war readjustment the general trend was reversed. This movement was especially marked in the Northern Region. In the case of Scotland, however, a steadily diminishing concentration is indicated, and in the North West the tendency for concentration to increase received an impetus in the immediate post-war years.

It is apparent then that considerable regional variations exist within the shipbuilding and ship-repairing industry. These variations may be explained by regional differences in the structure of the industry. Although detailed employment figures are, unfortunately, not available on this point for this earlier period, it is broadly true that employment on work of new construction predominated in the principal centres with the exception of the North Western Region. In this latter region, as in the remainder of the country, ship-repairing was in general more important than work of new construction.† The two divisions of the industry are influenced by different combinations of forces, and thus changes in the volume of activity and employment in each, especially in the short period, are not necessarily correlated.‡ In the past the volume of work of new construction has been characterized by wide fluctuations whilst, in the case of ship-repairing, the variations were not so wide.§ Trends, therefore, may be expected to differ from one area to

* The index of localization suggested by Professor Sargent Florence (*Investment, Location and Size of Plant*, pp. 34–35) cannot be derived satisfactorily from the employment statistics of the Ministry of Labour, since these differ considerably in scope and content from the employment data of the Census of Production.

† This suggestion appears to be borne out by the figures for the period 1943–49 given in the Appendix.

‡ Cf. "So far as we can gather there is no close correlation between the amount of new work and the amount of repair work in any given year". *Board of Trade, Industrial Survey of the N.E. Coast Area*, p. 244.

§ *Ibid.*, p. 245.

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another according to the degree of specialization in each area on new work or repairs.* Very little information on this aspect of the industry's employment structure is available for the earlier period and, indeed, the Ministry of Labour does not publish detailed statistics of the distribution of labour within the various sections even at the present time. However, information concerning the number of operatives employed in the shipbuilding and ship-repairing industry analysed according to work being done at dates between June, 1943 and March, 1949 was produced in reply to a Parliamentary question in May, 1949.† The table which appears in the Appendix has been constructed on the basis of this information, which it should be noted refers only to numbers of operatives employed and excludes all Admiralty dockyards. The figures are thus not directly comparable with the Ministry's published series relating to the industry, although it is possible to estimate the numbers of administrative, technical, and clerical workers employed by applying a factor derived from information available in Census of Production Reports.‡

From these figures it will be seen that, with certain war-time exceptions, employment on repairs in the years from 1943 to 1949 was greater than employment on new work in every region except Scotland and the North. At the same time, the three principal centres, considered as a group, employed more operatives on new work than on repairs during this period in spite of the fact that in the North Western Region two-thirds of the total labour force was actually engaged on repair work. In 1949 new work absorbed about two-thirds of the operative labour force in Scotland and the Northern Region, whilst in each remaining region it was repair work that absorbed a substantially greater proportion of the labour force. Although similar regional employment figures are not available for the years before the war, it is certain that this pattern of regional distribution of labour between new work and repairs was long-established, and that the deviations indicated by the statistics for 1943–49 were due almost entirely to the operation of exceptional war-time factors. Some support for this view is suggested by an estimate made early in 1939 of the volume of merchant tonnage under construction in Great Britain, from which it appears that out of a total of 507,000 gross tons, 464,000, or 92 per cent. of the total, were being built in Scotland and on the N.E. Coast.§

As already noted, this structural pattern of the industry provides a general explanation of the varying regional trends, since employment in ship-repairing is less unstable than employment on work of new construction—a feature which is clearly illustrated by regional employment trends between 1930 and 1938.‖ Further support for the view that the regional division of the industry between new work and repairs is significant in this connection is provided by the figures for Wales and the London and South Eastern Region during this period. In both areas the industry is almost exclusively devoted to ship-repairing and, in marked contrast to the trend in Scotland and the Northern Region, the index of employment of insured persons moved as follows:

	1930	1931	1937	1938
London and S.E.	100	70	121	123
Wales	100	87	100	100

The exceptional position of the North Western Region among the three principal centres of the industry may also be explained in this way since, although Merseyside and Barrow are very important centres of new construction, the Region employs a greater proportion of labour on repair work than on work of new construction. Hence, although the effects of employment fluctuations were more severe in the principal centres as a group than in the rest of Great Britain, the North Western Region in fact emerged from the difficult period between 1930 and 1938 with an expanded volume of employment, and approximated to the more favourable trend shown by the industry outside the principal centres. It is interesting, too, to note that between 1923 and

* It should be noted, too, that the fact that Admiralty dockyards are, in the main, located outside the principal centres of the industry may not be without significance in explaining regional variations.

† *Parliamentary Debates*, Vol. 464, Written Answers, col. 84. This material has been made available by courtesy of the Ministry of Labour and National Service.

‡ In the industry in Great Britain in 1924 and 1930 the number of administrative, technical and clerical workers represented approximately 8 per cent. of the number of operatives employed. See *Final Report of the 4th Census of Production*, Part II, pp. 320 and 324. By 1948 the proportion had risen to 10·6 per cent. See *Preliminary Report No.* 140, *Census of Production*, 1948.

§ *The Economist*, March 18th, 1939, p. 581.

‖ See p. 526. To some extent the situation may also be influenced by a certain amount of regional specialization in the construction of different types of vessel.

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1930, when new merchant tonnage constructed in the United Kingdom averaged some 1,186,000 gross tons a year, Scotland and the North improved their relative positions in the industry whilst the North Western centres declined in relative importance. From 1930 to 1938, however, when new merchant building was at a low ebb and averaged only 674,000 gross tons a year, the North Western Region increased in relative importance in the industry whilst Scotland and the Northern Region suffered a relative decline.*

The North Western Region also provides the exception to the general picture of the declining importance of the industry as a source of employment in the principal centres over the period from 1930 to 1947, being in this respect comparable to the rest of Great Britain outside these centres.† It would appear then that this trend too is associated with the division of the industry between new work and repairs. Technical factors may have influenced this divergence to some extent since, broadly speaking, in the engineering and allied trades repair work does not lend itself so readily as work of new construction to the application of improved techniques and the introduction of labour-saving methods and organization.‡ To the extent that this generalization holds good, one would, therefore, expect to find the ratio of labour to output altering more rapidly and to a greater extent in shipbuilding than in ship-repairing, and the divergent trends shown in the table on p. 526 may thus be due at least in part to the operation of this factor.§

The statistics of employment for the period 1943–49 suggest that ship-repairing is more widely dispersed throughout the country than is shipbuilding. Similarly it would also appear that naval work in general and naval repairs in particular are more widely dispersed than merchant work. This is apparent if aggregate employment in the principal centres is compared with that in the rest of the country, as is done in the following table derived from the Appendix, by expressing aggregate employment in Scotland and the Northern and North Western Regions as a percentage of employment in shipbuilding and ship-repairing in Great Britain as a whole:

Date	*All Types of Work*			*New Work*			*Repairs and Conversions*		
	Naval (%)	*Merchant* (%)	*Total* (%)	*Naval* (%)	*Merchant* (%)	*Total* (%)	*Naval* (%)	*Merchant* (%)	*Total* (%)
June, 1943	61·9	76·9	68·5	68·9	93·5	76·6	47·8	66·2	58·6
February, 1945	62·9	75·7	68·7	70·5	92·5	78·2	50·4	63·8	57·9
June, 1948	53·9	69·1	68·8	47·0	89·7	88·5	65·6	54·5	54·5
March, 1949	59·6	70·6	70·3	70·0	89·9	89·1	50·5	55·2	55·0

The three principal centres unquestionably appear to have enjoyed considerable advantages in respect of new work. Between June, 1943 and March, 1949 the volume of employment in this category fell in these centres by from 24 to 32 per cent. only, whilst in other regions the decline varied from 45 to 86 per cent. By contrast, however, they do not appear to have enjoyed any special advantages in respect of repair work, in which indeed they lost ground relatively to the remaining regions over the period. Their position in respect of maintenance of employment on this type of work was not as strong, for example, as that of the Southern and the London and South Eastern Regions. These differences also emerge from an examination of the extent to which the decline in naval employment was offset by expansion of employment on merchant work. In the case of employment on work of new construction, the main shipbuilding regions enjoyed a considerable advantage as compared with the rest of the country in the extent to which merchant work made up for the decline in naval work, whereas they did not enjoy any such advantage in the post-war re-alignment of ship-repairing, and in certain instances fared considerably worse than other regions.

The three principal centres presented fairly stable patterns of distribution of employment between new work and repairs and conversions in contrast to the remaining regions, in which considerable re-distribution in favour of repairs and conversions took place. The main con-

* *Lloyd's Register of Shipping.*
† See pp. 526–527
‡ Prefabrication, for example, can only be applied to a very limited extent in ship-repairing.
§ Over the period changes have occurred not only in methods but also in the technical characteristics of ships, and these may be reflected to some extent in the employment figures.

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clusion suggested by examination of the figures from this point of view is that although the war-time effort of the industry with its emphasis on new naval construction had, of necessity, to be concentrated largely in the three chief centres, the established balance was probably not unduly disturbed in their case, whereas the other regions, with their much smaller capacity, having to absorb the excess of the naval building programme which could not be dealt with in the main centres, found the balance shifted greatly in favour of new work during the war and, as the figures show, thus experienced a more drastic readjustment during the post-war years.

These figures, of course, throw no light upon the pre-war division of employment between repair work and work of new construction nor, in view of the special circumstances of the period, do they necessarily serve as a guide to the future balance of the industry in this respect. Lack of detailed information concerning the employment position in the past makes it difficult to arrive at any reliable conclusion on probable future trends. In 1932 it was cautiously estimated, in the Industrial Survey of the North East Coast Area, that the proportion employed in repair work was probably at least from one-eighth to a fifth of those employed in the industry as a whole.* The Census of Production shows that for the United Kingdom the proportion of the total labour force employed by repairers only was 22 per cent. in 1930 and 36 per cent. in 1935, figures which understate the real position, since much repair work is undertaken by firms which are also engaged on new construction.† On the basis of this very inadequate information, and assuming that the industry is likely to return to something approaching its pre-war proportions, it may be tentatively concluded that a considerable reduction of the labour force engaged on repairs is a possibility that may eventually have to be faced.‡

Examining the distribution of employment between naval work and merchant work, it will be seen that in Great Britain as a whole the war-time balance of employment was moderately in favour of naval work, which accounted for between 55 and 56 per cent. of all employment in the industry at the two given dates. In the case of new work, however, naval construction was an even more important factor in the employment situation, accounting for some two-thirds of the total employed in new work, whereas the position was reversed in respect of repairs and conversions, where from 55 to 58 per cent. of those employed were engaged on merchant work.

The post-war balance of the industry as a whole swung violently in favour of merchant work, which then accounted for over 96 per cent. of all employment in the industry, the position in respect of new work and of repairs being approximately similar at this later period. The main period of re-adjustment appears to have been between February, 1945 and June, 1948. Broadly speaking, there were three main phases in the post-war re-alignment of the industry, the first being the termination of the programmes of naval construction, conversion and repairs which was completed by 1947; the second being the expansion of work on new merchant vessels which began tentatively in 1945 and continued into 1949; and the third taking the form of an expanded programme of repairs to merchant vessels and reconversion of vessels from naval to mercantile purposes, a phase which reached its peak in 1948, declining thereafter as the programme of reconversion tapered off.

The overall changes in employment concealed very different movements in respect of naval work and merchant work. By February, 1945, the naval programme was tapering off and employment shrank to insignificant proportions by June, 1948. On the other hand, employment on merchant vessels, although a little lower in February, 1945 than in June, 1943, had increased considerably by June, 1948, but only to the extent of offsetting about 56 per cent. of the decline in employment on naval work. In comparing the trends of employment on new work and on repairs and conversions, it is apparent that by far the greater amount of the decline in total employment was accounted for by the fall in the volume of new work as a result of the cessation of naval building under the war-time programme. Expansion of employment on the building of merchant vessels offset the decline in employment on naval building by some 37 per cent. only in June,

* *Board of Trade, Industrial Survey of the N.E. Coast Area*, p. 245.

† *Final Report on the Fifth Census of Production*, Part II, p. 350.

‡ In this connection it is interesting to note that Mr. E. J. Hill, General Secretary of the Boilermakers' Society, in the speech referred to earlier, is reported to have said that ship-repairing cannot normally employ more than 50,000 persons.

By September, 1949, the number of operatives employed in ship-repairing in Great Britain had fallen to 82,302 (*Parliamentary Debates*, Vol. 469, Written Answers, col. 148).

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1948, and by about 41 per cent. in March, 1949. On the other hand, the decline in total employment on repairs and conversions was relatively small because the large decrease in naval employment of this type was to a much greater extent compensated by expansion of employment on merchant vessels, offsetting almost 94 per cent. of the decline in naval employment in June, 1948, and some 78 per cent. in March, 1949.

The balance of employment between naval and merchant work was, of course, greatly weighted in favour of naval work during the war, but it is probable that the post-war balance was also abnormal in its emphasis on merchant work. Here, again, lack of information concerning the pre-war employment position makes it difficult to obtain any guide to the probable future balance between naval and merchant employment. Warship tonnage, on the average, represented some 13·3 per cent. of total tonnage constructed in the United Kingdom in the years 1907–1913, and 5·5 per cent. of total tonnage in the period 1924–1930.* In 1930 the value of all types of work on naval vessels represented 7·1 per cent. of the gross output of the shipbuilding and ship-repairing industry.† These figures cannot be regarded as in any way a reliable guide to the employment situation in those years, since warship and merchant tonnage are not equivalent in labour requirements. However, since "the value of a warship ton for ton is much greater than for merchant ships and involves the employment of a greater amount of labour",‡ it may be suggested that naval employment in 1948 was probably on the low side, and that its slight recovery in 1949 represented the beginning of a trend towards more normal conditions in the industry in this respect.

Although, as already noted, naval work, like repair work, is more widely dispersed, it would nevertheless appear that the pattern of the industry in this respect is not as significant as the pattern of regional distribution of employment between new work and repairs. Whilst it is true that the dispersal of naval work strengthens the relative position of the rest of Great Britain as compared with the three principal centres of the industry—a factor which is reinforced by the location of Admiralty establishments mainly outside these centres—the indications are that the volume of naval work is subject to considerable fluctuations, even under peace-time conditions, and that by and large it represents only a relatively small portion of the industry's activity.

In attempting, finally, to bring together the salient points that have emerged from this review of employment trends in shipbuilding and ship-repairing, it can be said firstly that the industry, far from presenting a simple homogeneous pattern, is in fact exceedingly diverse. The decline of 59,000, or 25 per cent., in the number of operatives employed in 1949 as compared with 1943 covers very different sectional and regional trends. Hence, although the relative position of the three principal centres has in the aggregate changed very little in the past quarter of a century, important changes have occurred within the groups, where the position of the North Western Region has revealed trends in opposition to those operating in Scotland and the Northern Region.

These opposing regional employment trends are associated with the degree of specialization on new work or repairs existing in each region. The distinctive trends in Scotland and the Northern Region and the large measure of coincidence between the trends in the North Western Region and those in the regions outside the principal centres can be satisfactorily explained only in this way. The general trend of employment has on the whole been favourable to the principal centres of the industry since 1939 as a result of the high level of demand for new tonnage sustained throughout the period. During the last months of 1949 and throughout much of 1950 a decline in the demand for new merchant tonnage revived fears that the shipbuilding section of the industry might relapse into the unbalanced and depressed state prevailing in the decade before the second world war. In such a major recession, the position of the major centres of the industry, as in the past, would have been most vulnerable although, within the group, the indications are that the employment position would remain more buoyant in the North West than in Scotland and the North, in spite of the fact that in the down-swing of 1949–50 unemployment in the industry appeared to be more acute in the North Western Region than elsewhere. This, however, was due primarily to the fact that the programme of reconversion of vessels from naval to mercantile purposes, which was an important factor in the industry in the North West, was tapering off rapidly during 1949, and the final and most significant stages of this process of readjustment in the ship-

* *Board of Trade, Industrial Survey of the N.E. Coast Area*, pp. 242–43.
† *Final Report on the Fourth Census of Production*, Part II, pp. 322–23.
‡ *Board of Trade, Industrial Survey of the N.E. Coast Area*, p. 243.

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repairing section coincided with falling activity in new construction. Once the industry has adjusted itself to the new post-war situation, however, the greater specialization on repair work indicated in the case of the North Western Region should strengthen its position as compared with that of Scotland and the North in the event of a major slump.

Although for certain types of work ship-repairers have to operate within a highly competitive world market, there is nevertheless a wide field, mainly in voyage or running repairs, which is comparatively sheltered, and which contributes largely to the relative stability of the ship-repairing section of the industry. It is true that in a major depression the slump in shipping would adversely affect even this sheltered section but, as past experience has shown, the reaction would be much less severe than it would be in the case of shipbuilding. Moreover, although the post-1939 trends in employment on work of new construction indicate that in this sphere the principal centres enjoy considerable advantages over the remaining regions, they also show that these centres enjoy no distinct advantage over the rest of the country in respect of repair work and, in fact, in some cases have fared worse. This feature of the industry may be explained in large measure by the fact that in respect of voyage and minor repairs the different ports and regions are to a large extent non-competing groups. The principal centres may enjoy advantages in the case of major repairs, but this is a sector of the industry in which foreign competition is keen, and which in depression is more quickly and seriously affected by decisions to postpone repairs and lay-up ships.

Examination of the limited statistical evidence for the period from 1930 to 1947 suggests that the industry as a whole was becoming more widely dispersed. The extent to which it was concentrated in the three principal centres diminished considerably during this time. This movement, however, took place only in Scotland and the Northern Region. The North Western Region shared with the rest of the country the converse movement. This suggests that the greater dispersal of the industry was associated firstly with the relatively more stable position of ship-repairing during the decade 1930–39, and secondly with the great wartime expansion of the industry. Since, however, shipbuilding remained at a relatively high level in the principal centres in the post-war period whilst war-time programmes of building in other regions were rapidly liquidated, the trend towards greater dispersal might be expected to weaken, and possibly to be eventually reversed. The indications are that this change began in 1947. The ultimate extent and direction of change in regional concentration will, of course, be determined in the long run by the interaction of the various forces influencing the two main divisions of the industry to which reference has already been made.

In conclusion, the regional distribution of the industry appears to have altered little during the past quarter of a century, although the available statistical evidence appears to point to a slight decline in the relative importance of the principal centres, with the North Western Region again providing the exception within the group. Since relative importance is being measured in terms of employment afforded, this apparently limited movement may reflect mainly greater technological improvements in shipbuilding than in ship-repairing. However, it is also obvious that any decline in world demand for new tonnage or the emergence of increased foreign competition in this field will, since its effects will be felt mainly in the three principal shipbuilding centres of Great Britain, tend to produce a re-distribution of the industry relatively more favourable to the remaining regions. It is impossible to predict the future course of world shipbuilding and Great Britain's share in it, but the general indications over the past fifty years are that the British share has declined considerably. In terms of tonnage launched, the share of world output accounted for by Great Britain and Northern Ireland fell from 71·5 per cent. in 1897 to 51·2 per cent. in 1930,* and although output of new merchant tonnage more than doubled in the United Kingdom during the past decade as compared with the period from 1930 to 1939, the gross tonnage under construction at the end of 1951 represented only about 40 per cent. of the tonnage being built throughout the world.† During 1951, however, mainly under the influence of conditions associated with international political developments, merchant shipbuilding orders received by British shipyards reached a very high level and, with a total order book at the end of the year of some 6·5 million gross tons, the shipbuilding section of the industry seems assured of full employment for at least the next two years.

* *Industrial Survey of the N.E. Coast*, pp. 276–77.
† *Lloyd's Register of Shipping.*

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APPENDIX

Numbers of Operatives Employed in Various Branches of Shipbuilding and Ship Repairing (excluding Admiralty Dockyards) in Great Britain and in certain Administrative Regions at Specified Dates

Region		All Types of Work			New Work			Repairs and Conversions		
		Total	Naval	Merchant	Total	Naval	Merchant	Total	Naval	Merchant
London and S.E.										
June,	1943	17,732	11,894	5,838	5,415	5,100	315	12,317	6,794	5,523
February,	1945	16,954	11,297	5,657	4,972	4,691	281	11,982	6,606	5,376
June,	1948	14,682	308	14,374	1,056	164	892	13,626	144	13,482
March,	1949	13,379	357	13,022	1,091	99	992	12,288	258	12,030
Eastern										
June,	1943	5,903	5,318	585	3,738	3,571	167	2,165	1,747	418
February,	1945	5,553	4,573	980	2,829	2,584	245	2,724	1,989	735
June,	1948	3,087	288	2,799	1,130	272	858	1,957	16	1,941
March,	1949	3,041	166	2,875	1,097	144	953	1,944	22	1,922
Southern										
June,	1943	16,271	13,752	2,519	9,789	9,605	184	6,482	4,147	2,335
February,	1945	15,386	12,161	3,225	7,733	7,520	213	7,653	4,641	3,012
June,	1948	12,838	515	12,323	2,839	484	2,355	9,999	31	9,968
March,	1949	11,924	981	10,943	2,839	405	2,434	9,085	576	8,509
South-Western										
June,	1943	10,215	6,970	3,245	5,229	5,191	38	4,986	1,779	3,207
February,	1945	9,304	6,794	2,510	4,263	4,248	15	5,041	2,546	2,495
June,	1948	6,014	33	5,981	833	15	818	5,181	18	5,163
March,	1949	5,547	88	5,459	964	11	953	4,583	77	4,506
East and West Ridings										
June,	1943	8,234	3,849	4,385	3,581	1,916	1,665	4,653	1,933	2,720
February,	1945	7,844	3,092	4,752	3,372	1,373	1,999	4,472	1,719	2,753
June,	1948	6,426	184	6,242	2,042	91	1,951	4,384	93	4,291
March,	1949	6,069	236	5,833	1,965	109	1,856	4,104	127	3,977
North Western										
June,	1943	38,914	16,631	22,283	12,176	10,265	1,911	26,738	6,366	20,372
February,	1945	38,585	17,749	20,836	11,496	9,312	2,184	27,089	8,437	18,652
June,	1948	30,012	713	29,299	8,707	336	8,371	21,305	377	20,928
March,	1949	30,112	2,040	28,072	9,311	907	8,404	20,801	1,133	19,668
Northern										
June,	1943	56,379	26,126	30,253	39,285	19,159	20,126	17,094	6,967	10,127
February,	1945	53,105	23,943	29,162	36,426	16,293	20,133	16,679	7,650	9,029
June,	1948	43,660	141	43,519	27,215	132	27,083	16,445	9	16,436
March,	1949	43,085	207	42,878	27,948	195	27,753	15,137	12	15,125
Scotland										
June,	1943	61,766	37,513	24,253	45,033	30,402	14,631	16,733	7,111	9,622
February,	1945	58,596	34,262	24,334	42,559	27,270	15,289	16,037	6,992	9,045
June,	1948	45,911	858	45,053	28,637	461	28,176	17,274	397	16,877
March,	1949	46,512	1,555	44,957	30,740	972	29,768	15,772	583	15,189
Wales										
June,	1943	9,901	4,121	5,780	1,132	1,011	121	8,769	3,110	5,659
February,	1945	9,654	4,042	5,612	1,334	1,079	255	8,320	2,963	5,357
June,	1948	7,838	109	7,729	228	—	228	7,610	109	7,501
March,	1949	7,672	476	7,196	161	10	151	7,511	466	7,045
Great Britain										
June,	1943	229,381	129,627	99,754	126,071	86,862	39,209	103,310	42,765	60,545
February,	1945	218,823	120,670	98,153	115,588	74,938	40,650	103,235	45,732	57,503
June,	1948	173,660	3,174	170,486	72,898	1,980	70,918	100,762	1,194	99,568
March,	1949	170,381	6,382	163,999	76,350	2,962	73,388	94,031	3,420	90,611

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The Sources and Nature of Statistical Information in Special Fields of Statistics

Statistics Relating to the Petroleum Industry, with Particular Reference to the United Kingdom

By A. L. King

A brief examination of the character of petroleum and of the economic structure of the world petroleum industry is a necessary introduction not only to international petroleum operations but also to an understanding of the particular statistics of an individual country such as the United Kingdom. This paper is, therefore, divided into four main parts:

I. Introduction—describing the character of the products with which the industry is concerned and certain economic factors which have been influential in their development.
II. World Statistics*—presenting a general picture of the nature and sources of world statistics.†
III. U.K. Statistics—developing a composite and relatively detailed analysis of operations in the United Kingdom and of the data available.
IV. U.S.A.—a final section making reference to the special characteristics of the U.S.A. in the field of statistical analysis.

I. Introduction

The operations of the petroleum industry cover a wide range, starting with the search for crude oil deposits and ending with the sale of finished products, often in small quantities to private individuals. After the exploration stage the output of one phase of the industry is the raw material of the next; petroleum statistics therefore relate to a series of activities which are comparable in their scope and diversity with the functions of a number of different industries concerned in the handling of different commodities.

The petroleum industry's basic raw material—crude oil—is chemically a mixture of hydrocarbons, and it may be processed into a wide range of products. Most crude oils and products derived from them are liquid at normal pressures and temperatures, but natural gas occurs in many deposits and gases are produced by the refinery processes; certain products, notably bitumen and paraffin wax, are solids.

It is proposed in this paper to deal essentially with those operations which begin when crude oil has been discovered in commercial quantities, and in doing so it is not intended to elaborate either on the exploration stage or on the major considerations in regard to the assessment of crude

* Statistics of petroleum activities in the Soviet Union and Russian-controlled territories are sparse; the figures published by the governments thereof are difficult to interpret and generally are expressed as percentages. Except for reference in the footnote to Table 3, p. 539, to certain broad estimates of production which have been advanced, petroleum operations within the Soviet sphere are therefore not considered in this paper. Since the Iron Curtain countries form a practically autarkic bloc with regard to petroleum, the scope of the paper is not curtailed in so far as the rest of the world is concerned.

† The events which have taken place in Persia during the period that this paper was being written are widely known. No attempt, however, has been made to anticipate any developments which might arise as a result of the Oil Nationalization Act passed in the Majlis on April 30th, 1951.

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oil reserves. With regard to the latter, a brief sub-section is included in Section II of the paper, but with particular emphasis on the extreme care with which this subject must be approached.

Crude oil is, in nearly all cases, unsuitable for use in the form in which it is obtained from the well. It has to be refined, and it is noteworthy that the specialized methods used during the process of refining and the variety of products which can be produced have now been developed to a stage when there are virtually no waste products. Although on occasion other fuels such as coal may be used, the energy necessary for the refining activities is generally supplied from the crude oil being treated—a significant feature when relating the "product" out-turn to the "crude" input of a refinery or group of refineries. It is equally necessary to appreciate that the product from any given refinery may be finished and ready for consumption, but alternatively may be an unfinished oil, either forming the raw material for another refinery or required for blending.

A further feature of statistical significance is that transportation presents a special problem to the industry from two main aspects, first the transportation of the crude from the well to the refinery, and secondly from the refinery to the zone of consumption. The industry's needs in this respect are primarily met either by pipeline or by ocean tanker, and reliable data on these facilities can be obtained.

The heavy international movements of oil by ocean tanker are recorded as exports and imports, both of which are naturally the subject of statutory supervision, and in regard to which statistics are accordingly often available from governmental sources. Finally, the variety and complexity of consumers and of the uses of the various products provide a wide field for statistical research and analysis.

Character of Petroleum Products

Reference has been made to the wide range of products obtained from crude oil, and a large proportion of the available statistics relate to individual products or groups of products. The ensuing section sets out a broad description of the major products and describes some of their uses. It should be emphasized that this list and the subsequent statistics referred to do not cover the rapidly developing chemical products for the production of which petroleum is now being used as a feedstock. Such products are not normally referred to as "petroleum products."

The order of products in the list given below is not indicative of their relative importance, but follows the customary practice of listing products in accordance with specific gravity, the lightest product heading the table.

Refinery Gas

Refinery gases are either piped from the refineries or the butanes and propane they contain may be liquefied under pressure and marketed in steel bottles.

Used as industrial and domestic fuel, as refinery fuel, and for the manufacture of carbon black.

Gasoline

This may be either aviation spirit, motor spirit or white spirit. White spirit is used mainly for dry cleaning, the manufacture of polishes and as a solvent in paint and varnish.

Kerosene

(*a*) Burning Oil—a fuel for lamps, cookers and heaters and for gas turbine aircraft engines.
(*b*) Vaporizing Oil—a fuel for agricultural tractors, stationary engines and small marine craft.

Lubricating Oil

For all forms of lubrication and, in addition, for a number of specialized industrial processes.

Gas/Diesel Oils

Used for gas-making, as fuel for diesel engines (marine, road and stationary), for small automatic central-heating plants, and for other specialized burning purposes. Also being developed as fuel for gas turbine engines.

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Fuel Oil

Used for boiler firing (land and marine), and for industrial furnaces.

Paraffin Wax

For the manufacture of candles and polishes and for waterproofing and insulation.

Bitumen

Used in road construction, the manufacture of roofing felt, floorcloth and waterproofing paper, for the protection and insulation of electric cables, the coating of pipelines, the lining of storage tanks and in hydraulic construction.

Capital Structure of the Industry

It is not proposed to examine in detail the capital structure of the industry or to elaborate on the sources of information available. It is, however, essential to emphasize that the nature of the petroleum industry's operations has a profound influence on its capital structure, and is in turn reflected in the character of petroleum statistics and in the problems which a study of them presents.

Every phase of oil industry operations requires a heavy capital outlay. The extraction of oil must be prefaced by many specialized forms of exploration and by long and costly processes of drilling. The refining of oil requires elaborate equipment. Transportation and specialized forms of distribution likewise require heavy capital expenditure and, when capital expenditure is great, the standing interest charges are stable and high at whatever level an industry operates.

In these circumstances it is economically essential that, as far as is possible, all resources employed should be utilized to maximum capacity. It is this all-important need to maintain "capacity" operation that is mainly responsible for vertical integration in the world-wide industry so that, in the main, all the important operating companies and groups concern themselves with every phase of operations, from the first stage of exploration to the last of distribution and marketing.

As the result of such vertical integration statistical data about certain aspects of the industry's operations are apt to be treated as a purely domestic matter. This tends to make statistics of international petroleum operations patchy, relatively profuse in the case of production and the consumption of individual countries but scarce and difficult of interpretation in the range between.

Refining

A brief reference to the characteristics of refining is necessary for a proper appreciation of petroleum statistics.

The various products are not sharply distinguished from one another. The refining process is basically one of distillation, and the difference between the bottom grade of one product and top grade of the next is therefore in the first instance indefinite. The proportion of products obtained from the straight distillation of a given crude is often not in conformity with the relative needs of consumers. There are, however, a number of special processes which broadly make use of pressure and heat to modify the chemical structure of the natural product being treated. By using one or more of these special processes the yield of a particular product may be increased to a material extent, and this gives the petroleum refinery a considerable degree of flexibility in meeting the changing needs of the market.

The need for this flexibility is demonstrated by the historical development of the industry. At the end of the 19th century kerosene was the product mainly in demand; the flexibility of refineries was small, and motor spirit was run to waste as an inconvenient by-product. As the demand for motor spirit became paramount, the industry developed methods of increasing the yield of this product from a given crude oil. The use of these specialized techniques has now been developed to a very high degree and, although there are limits determined by the character of the crude being processed, a modern refinery can vary its out-turn to meet a very wide range of requirements.

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Units of Measurement

Before proceeding to a detailed examination of the various classes of statistics, it must be pointed out that there is one drawback which applies to all sectors of the industry's activity. Since petroleum is a liquid its measure can be stated in volume or in weight. While weight is a constant, volume varies, of course, with temperature, and in practice this often presents a considerable problem when conversion from one to the other is necessary. Accordingly, the specific gravity of any individual product is of particular importance, and frequently enters into statistical calculations dealing with petroleum.

For some phases of the industry's operations, for instance crude oil production, measurement is normally in terms of volume expressed either in barrels or barrels daily. In others such as refining, a measure of nominal or rated capacity is given in terms of "barrels daily" in the U.S.A., but may be given in metric tons on the Continent of Europe and long tons in the United Kingdom, though the use of barrels daily is now becoming more general. Marketing operations are reported in barrels or U.S. gallons in the U.S.A., largely in litres on the Continent and imperial gallons in the United Kingdom. In this connection it should be noted that the standard "barrel" in the U.S.A. is equivalent to 42 U.S. gallons, which, in turn, is approximately 35 imperial gallons.

Where there is simply a question of converting one measure of volume to another, no great difficulty arises. When the problem is to convert from weight to volume or vice versa, great caution must be exercised. Since the conversion factor varies with the specific gravity products should not be aggregated but, except for rough calculations and approximations, should be converted individually. It should also be taken into account that the generic name for a product can cover a fairly wide range of specifications; thus the conversion factor for kerosene will vary from country to country. For accurate work it is essential that the conversion of statistics to common units should be carried out at as early a stage as possible in the collation of the data.

Statistical Treatment of Petroleum Operations

While there will be many examples of research primarily or even exclusively concerned with one particular aspect of the industry, a broader study demands a proper co-ordination of the various phases of operation. Unless the subject-matter requires a particular approach, a logical sequence of subdivision is as follows:

1. Production of crude oil, natural gasoline and substitute fuels.
2. Refinery operations.
   (*a*) Input.
   (*b*) Out-turn.
3. Transportation.
4. Consumption.

It is accordingly proposed to follow this sequence in the ensuing sections.

The term "consumption" is used throughout the paper, but it will be found that in a number of countries, particularly the U.S.A., the term "domestic demand" is customarily used in exactly the same context. It is appropriate to record, moreover, that in the U.S.A. the expression "total demand" is recognized as referring to domestic demand plus total exports.

An ideal set of statistics would make possible the exact reconciliation of each of the classifications from 1 to 4 above. In fact, of course, the reality is far from this ideal picture, and it is of more importance to assess the quality of the various classes of information than to aim at achieving such a reconciliation.

II. World Statistics

The descriptive section in the Introduction on the character of petroleum products demonstrates that, with the prominent exceptions of lubricating oil and bitumen, the major importance of the

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products of crude petroleum lies in their contribution as a source of energy. The size of this contribution in relation to other sources of energy can be assessed by analysis of data, as in Table 1 below, estimated from private sources.

TABLE 1

Estimated Major Sources of Energy, 1950

(*Percentages*)

Source of Energy	*World (excl. U.S.S.R. and Satellites)* %	*U.S.A. (Inland Consumption)* %	*U.K. and Irish Republic (Inland Consumption)* %
Coal and lignite .	45	31	87
Liquid petroleum .	35	41	12
Natural gas . .	13	23	—
Hydro electricity .	7	5	1
Total all sources .	100	100	100

Production

(a) *Mineral Sources of Production of Crude Petroleum*

There are, in fact, three main sources of production of crude petroleum or of petroleum products in a finished or semi-finished condition—petroleum deposits (liquid and gaseous), shale and coal.

It is necessary at the outset to give some indication of the relative importance of each of these sources, as in the following table:

TABLE 2

Estimated World Production of Crude Petroleum and Products Derived from Shale Oil and Coal (excl. U.S.S.R. and Satellites)

(*Percentages*)

Sources of Production	1949
Derived from petroleum deposits	
Crude Oil	77·8
Natural gasoline	1·6
Natural gas (calorific equivalent in tons of crude oil)	20·2
Total petroleum deposits . . .	99·6
Derived from other sources	
Shale oil	0·2
Coal products	0·2
Total other sources	0·4
Grand total	100·0

It will be seen from the above that, from the point of view of world supply, other sources of refined products are negligible compared with petroleum deposits. Subsequent references in this paper to refined products will therefore normally refer to those derived from petroleum deposits, though the figures may from time to time include small quantities of products derived from other sources.

It is important, however, in using other published sources, to keep in mind that the term "crude petroleum," though used frequently to mean crude oil, can also include natural gas, natural gasoline, or even shale oil. In using statistics of the production of crude petroleum, it may therefore be essential to ascertain the precise definition of the term in each case.

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(b) *Geographical Sources of Production of Crude Petroleum*

From almost all aspects, economic, political, and social, the world pattern of production of petroleum products is of fundamental importance, and a significant feature of the natural distribution of petroleum is that, except in the U.S.A. and U.S.S.R., most deposits of any size have been found in areas remote from the industrialized countries where petroleum products are mainly required. The following table shows the major production areas of the world:

TABLE 3

World Production of Crude Oil and Natural Gasoline
*(excl. U.S.S.R. and Satellites)**

(Thousands of Barrels Daily)

Geographical Source of Production	1938	1949	1950
North America	3,587·0	5,710·7	6,185·5
South America and Caribbean	723·9	1,577·5	1,771·8
Western Europe	13·3	32·1	41·4
Middle East	332·4	1,446·6	1,797·5
Other Asia	35·9	14·2	18·6
Other Africa	0·1	0·3	0·8
Oceania	171·7	189·9	222·2
Total world production	4,864·3	8,971·3	10,037·8
,, ,, ,, in thousands of long tons per annum†	238,750	440,080	493,010

* Various estimates of crude oil production in the U.S.S.R. and satellites are published from time to time in the press, various periodicals and elsewhere. Published sources include the U.S. Bureau of Mines, Petroleum Information Bureau, the *Oil and Gas Journal* and *World Oil*. For the purpose of forming some idea of the relative magnitude of Soviet-controlled production the estimate for 1950 of 42 million tons, as published in the Dutch and French editions of the Annual Report of the Royal Dutch Petroleum Company, is probably a sufficiently good indication.

† Total world production shown in tons for comparability with U.K. and other national statistics, which are neither available, nor easily expressed, in terms of barrels daily.

Source.—Based on Shell Transport & Trading Co., Ltd., Annual Reports.

The main centre of petroleum production in North America is the United States, particularly the U.S. Gulf area and the Pacific Coast, but production in Canada is expanding, and recent discoveries in Alberta and Saskatchewan are likely to have considerable long-term significance. Developments in the Middle East have been mainly in Iraq, Persia, Kuwait and Saudi Arabia, while production in Oceania is in Indonesia and Borneo.

(c) *Statistical Sources*

There is a great deal of information published about the domestic petroleum operations of a large number of countries, but reliable published statistics covering the oil industry's operations in the world as a whole are extremely rare. Owing to its world-wide interests and its commanding position in the international petroleum industry, the U.S.A. has the best sources from which world oil statistics may be compiled.

A few years ago the U.S. Government recognized the growing need for world oil statistics, and the Departments of Commerce and the Interior published some annual figures. In particular, the Department of the Interior (Bureau of Mines) produced tables summarizing statistics already published in its *International Petroleum Trade*, an official journal giving details of the operations of the industry in selected individual countries. These summary tables include statistical information about various aspects of overall oil operations; they are produced, however, after a considerable lapse of time, are admittedly based on incomplete figures and, though believed to be indicative of the major developments in the world petroleum industry, do not claim to be a complete and satisfactory analysis.

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Other attempts to obtain the desired statistical data have been more successful, and although it is based on figures which are partially estimated, the Bureau of Mines now publishes a statement, *World Petroleum Statistics*, containing a table which, in its first column, provides probably the most serviceable source of production statistics available. It is published monthly and an annual issue showing the operations for the past calendar year is also available; the following table summarises the 1950 annual issue:

TABLE 4

World Supply and Demand—Crude Petroleum (excl. U.S.S.R. and Satellites), 1950

(*Thousands of Barrels*)

Area	*Production*	*Imports*	*Exports*	*Crude Runs to Stills*	*Other Demand and Losses*	*Stock Change*
North America . . .	2,073,123	261,498	50,910	2,259,272	27,474	−3,035
South America and Caribbean	644,059	322,323	490,750	468,253	5,637	1,742
Western Europe . . .	14,113	274,645	64	289,574	421	−1,301
Middle East	657,374	51,639	377,171	318,942	3,286	9,614
Other Asia	5,918	10,347	—	15,107	237	921
Other Africa . . .	329	5,910	—	6,072	34	133
Oceania . . .	81,115	5,460	11,300	75,139	356	− 220
Total	3,476,031	931,822	930,195	3,432,359	37,445	7,854

Source.—U.S. Bureau of Mines, *World Petroleum Statistics*, 1950.

The table is set out in the Bureau of Mines publication in this form, broken down into country statistics sub-totalled into the areas shown above, and it will be seen that, in addition to the production figures, it incorporates data on imports, exports, crude runs to stills, other demand and losses, and changes of stock, so as to provide a broad supply and demand analysis of crude petroleum throughout the world, and thus linking the production stage under consideration in this sub-section with the refining stage commencing on p. 542. Table 4, incidentally, provides an example of circumstances in which it is necessary to be precise as to the implication of the term "crude petroleum". The Bureau of Mines figures do not include natural gasoline, and the more comprehensive nature of Table 3 should not, therefore, be overlooked.

Some elaboration of the headings used in this table is necessary for a proper understanding of their significance. The term "Crude Runs to Stills" indicates the amount of crude petroleum which is fed to refineries to undergo the refining processes, whilst "Other Demand and Losses" is, in fact, a balancing figure incidental to the refining processes and the direct use of crude oil as refinery fuel.

The table then assumes a coherent form in which the constituents of supply are respectively production, imports, and stock, and the constituents of demand are exports, crude runs to stills, and other demand and losses. The column showing "Stock Change" can therefore be regarded as a measure of the extent to which the combined total of production and imports exceeds, or alternatively fails to meet, the combined demand.

In the same publication, a parallel monthly statement analysing the production of major refined products is also presented, and this equally, by annual summarization, can provide the basic data of refinery output. The Bureau of Mines intends to extend these statistics, in due course, to a regular supply and demand survey of the major refined products of the industry.

More detailed statistics of crude oil production by individual countries are published monthly by the U.S. Bureau of Mines and the *Oil and Gas Journal* and, in addition, *World Oil* annually brings up to date a complete record of the crude oil production of the world by countries for each year from 1857. Part of this statistical record is summarized in the following table, which shows the annual production of North America at the end of each 10-year period:

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TABLE 5

North America—Annual Production of Crude Oil

(*Thousands of Barrels*)

Year	*Canada*	*Mexico*	*United States*	*Cuba*	*Total North America*
1860	—	—	500	—	500
1870	250	—	5,261	—	5,511
1880	350	—	26,286	—	26,636
1890	795	—	45,824	—	46,619
1900	913	—	63,621	—	64,534
1910	316	3,634	209,557	—	213,507
1920	196	157,069	442,929	—	600,194
1930	1,522	39,530	898,011	—	939,063
1940	8,591	44,036	1,353,214	142	1,405,983
1950	28,904	72,118	1,971,845	68	2,072,935

Source.—World Oil (International Operations Issue), July 15th, 1951.

These figures refer only to crude oil, and natural gasoline must be included if the overall supply position of the industry is being considered.

Crude Oil Reserves

As is pointed out in the introduction, this is a subject which must be approached with caution, and with which, in fact, only a production expert is in any way qualified to deal. A distinction must be made between proven reserves and possible reserves, for only a small fraction of the possible oil-bearing deposits have been surveyed and proven.

Proven reserves are the quantities which it is estimated can be recovered from fields which have been proved by drilling through the techniques of recovery in use in those fields. They are conservatively based upon technical data derived from the testing of areas by drilling, and are increased not only when new oilfields are discovered but when, in the course of the development of an existing oilfield, further knowledge of its structure comes to light.

The possible reserves, on the other hand, are based, not upon exact data, but upon geological estimates of areas of the world in which oil is likely to be found. Such estimates are bound to be speculative and in fact are usually conjectural.

The current position with regard to proven reserves of petroleum deposits has been set out in *World Oil* and is reproduced in Table 6 below:

TABLE 6

Estimated World Crude Oil Reserves

(*excl. U.S.S.R. and Satellites*). *Proved and indicated as at January 1st, 1951*

(*Thousands of Barrels*)

Geographical Source	*Thousands of Barrels*
North America	28,722,224
South America and Caribbean	10,650,000
Western Europe	247,200
Middle East	48,180,000
Other Africa	3,200
Other Asia	115,500
Oceania	1,250,500
Total world reserves	89,168,624

Source.—World Oil (International Operations Issue), July 15th, 1951.

Though the proven reserves shown above are, as far as is known, ultimately recoverable, it must be realized that the rate of extraction is partly determined by underground conditions which

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vary from field to field and by the broad techniques it is possible to apply. The actual recovery achieved over the life of any particular field under these influences varies widely from one field to another, but can be estimated on the average at about 25 per cent. of the existing oil.

Refining

In examining the supply pattern of the industry, the location of refineries is a factor that must be taken fully into account, and the statistics cannot be treated as if crude oil were identical with refined products.

Crude oil can be refined either at or near the seaboard of the zone of production or near the area of consumption. In most cases, purely economic considerations weigh in favour of refining crude oil as nearly as may be to the source of production; in these cases there is a minimum of waste incurred in transporting that part of the oil which is used or lost in the refining process. However, a variety of other more complex factors may operate to favour the siting of refineries in either the producing or the consuming zones; fiscal discrimination against imported products, questions of military strategy, the development of petroleum products as chemical feedstocks and the attitude of some of the governments where production is found all play a part. In post-war years, moreover, the need of various countries to husband their resources of particular currencies has been an important influence in determining the location of new refinery capacity.

The result is that, although much of the world's refining capacity is situated in the zones of production, important parts are to be found in some of the consuming areas. The European refinery expansion programme is a prominent example of the construction of refineries away from the source of production.

The following table gives the particulars of refining capacity in various parts of the world. As has been mentioned in the note to Table 3, the available data for world capacity is quoted in barrels daily, whereas most refinery statistics for the U.K. are in tons, and as no overall ratio of volume to weight is possible, accurate conversion from barrels to tons is not easily made.

TABLE 7

World Nominal Crude Oil Refinery Capacity (excl. U.S.S.R. and Satellites) at End of 1938, 1949 *and* 1950

(*Thousands of Barrels Daily*)

Refinery Location	1938	1949	1950
North America[1] . . .	4,786	7,247	7,565
South America and Caribbean .	707	1,074	1,289
Western Europe . . .	316	735	918
Middle East	337	967	973
Other Asia	93	49	90
Other Africa	7	19	19
Oceania	184	193	223
Total world refinery capacity .	6,430	10,284	11,077

[1] Including shut-down capacity in U.S.A.

Source.—Oil and Gas Journals, 1950–51.

It will be seen that refinery capacity in the Western Hemisphere was in 1950 nearly four times that of the Eastern Hemisphere, but with the growing importance of the Middle East as a source of crude oil, to which reference has already been made, the construction of new refineries is likely to proceed considerably more rapidly in the old world than in the new.

A most useful source of statistics of refining available at present is the Organization for European Economic Co-operation (O.E.E.C.), but there can be no guarantee that this body will remain permanently in being. The problem, therefore, is to point to permanent world-wide sources of information that will enable continuity of refining statistics to be maintained. Whilst various oil journals contain statistics of refineries often in special issues by such publications as *World Petroleum*, *Oil and Gas Journal* and *World Oil*, the U.S. Bureau of Mines *World Petroleum*

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Statistics gives the most comprehensive picture of the intake and out-turn of world refineries. Details of refineries in these journals are concerned mainly with future building or extension programmes and some particulars of plant capacities.

It must be noted, however, that these statistics generally refer to rated, i.e., nominal, capacity. The nature of a modern refinery allows considerable flexibility in its operation, and an out-turn greater than its rated capacity can be made available should the occasion demand, if the out-turn of certain high-grade products, entailing the use of specialized processes, is curtailed. Moreover, the use of some grades of crude oil in certain refineries may reduce considerably the nominal capacity.

Transportation

The organization and development of specialized forms of transport are designed to meet three major operations—transportation from the oilfields to the seaboard or refinery, from these to the port of importation, and from there to the consumer. In this paper, though it would not be possible to enter into the subject in detail, a short account is given of the statistics relating to the first two of these operations; no description of wholesale and retail transportation is attempted, since the methods adopted are not entirely confined to the petroleum industry.

There are two forms of bulk transport which are almost peculiar to the petroleum industry, pipelines and ocean tankers; both have the common feature that they cannot properly be adapted to the service of any other commodity, though there are certain exceptions to this rule. The basic function of the pipeline is the movement of crude oil from individual wells to refineries or shipping terminals, and the movement of products from refineries to bulk storage. When the market lies inland away from the refinery, as in part of the U.S.A., pipelines are of special importance.

The two methods of transport are thus basically complementary, and only enter into competition in special cases; the profitability of pipelines in competition with tankers depends on the particular circumstances. Broadly a trunk pipeline will move crude or products less economically than tankers, provided that the comparison is like with like. However, where the use of a pipeline shortens the distance or avoids canal dues it may be a more economic method of transport, while, in some circumstances, its use may be preferable for strategic or security reasons.

Though the number of main pipelines of sufficient grandeur to arouse general interest is few, smaller lines perform equally important tasks in their different spheres. Information published on pipeline operations and construction is mainly in terms of actual or projected annual throughputs, and few statistics are published on monthly throughputs; most of the American journals previously mentioned report annual statistics, *World Oil*, for example, publishing once a year an "International Operations" issue which gives detailed information on pipelines in most countries; the following table gives an extract:

TABLE 8

Crude Oil Pipelines of Iraq

Origin	*Terminus*	*Length (Miles)*	*Diameter (Inches)*	*Capacity (Barrels Daily)*	*Year Completed*
Kirkuk	Haifa	620	12¾	90,000	1934
Kirkuk	Tripoli	530	12¾		1934
Kirkuk	Haifa	620	16	180,000	Suspended
Kirkuk	Tripoli	530	16		In use
Kirkuk	Banias	556	26–32	275,000	Building
Naft Khaneh	Alwand	24	4–6	8,600	1927
Zubair	Fao	72	12¾	50,000	Building

Source.—*World Oil* (International Operations Issue), July 15th, 1951.

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Statistics of tanker tonnage in operation and under construction can be readily obtained in publications issued by the Chamber of Shipping, Lloyd's Register of Shipping, and from brokers' reports, such as from John I. Jacobs & Co., Ltd. The latter compile a useful series giving details of the World Tanker Fleet by flag which is published approximately every six months in *Lloyd's List*; the information is given in two tables, one according to motor and steam-driven vessels, the other according to age. A summary of the information contained is given below for 1950.

TABLE 9

World Tanker Fleet (excl. U.S.S.R. and Satellites).

(*Thousands of D.W. Tons*)

Country	1950
U.S.A.	8,608
Great Britain	5,684
Norway	3,809
Panama	2,720
Holland	872
France	985
Italy	850
Canada	304
Sweden	525
Argentine	311
Venezuela	142
Japan	373
Spain	189
Denmark	318
Others	2,769
Total world tanker fleet	28,459

Source.—Lloyd's List and *Shipping Gazette.*

Figures also appear from time to time in various American journals.

International movements of crude oil and products should in theory be automatically resolved into exports and imports; in practice it is not always easy to reconcile the two. By using the export figures of the producing countries and supplementing these with the data obtained from tanker movements as published in such journals as *Lloyd's List*, it is, however, possible to build up consolidated information covering the major movements of oil in the world as a whole. Such figures as must be used, however, are apt to be published with a considerable time lag, and only the major commercial concerns can compile up-to-date information, which is released by them from time to time in the various trade journals already mentioned.

The U.S.A., which forms by far the largest market in the world, supplies most of its own requirements; however, their imports and exports, though small in relation to the U.S. domestic position, are of considerable importance to the rest of the world. The U.S.A. imports fall largely on the Caribbean, but are beginning to be partly met from the Middle East.

Europe is the next largest market, and since European indigenous production is relatively small, most of its requirements have to be supplied from imports, mainly from the Caribbean and Middle East.

The other markets may be broadly delineated as Canada, South America, S.E. Asia and the Far East and Oceania. Both Canada and South America are partially supplied from their own production, and in addition from the Caribbean and the U.S.A. The Eastern Hemisphere markets are partially supplied from Indonesia and Borneo, but also have imports from the Middle East.

Consolidated information on these lines has been charted in the diagram on the opposite page.

Consumption

In the U.K. section a detailed study is made of the various sources of information which are concerned in one way or another with the consumption of petroleum products. The character of such internal information essentially varies between almost every individual country, and no

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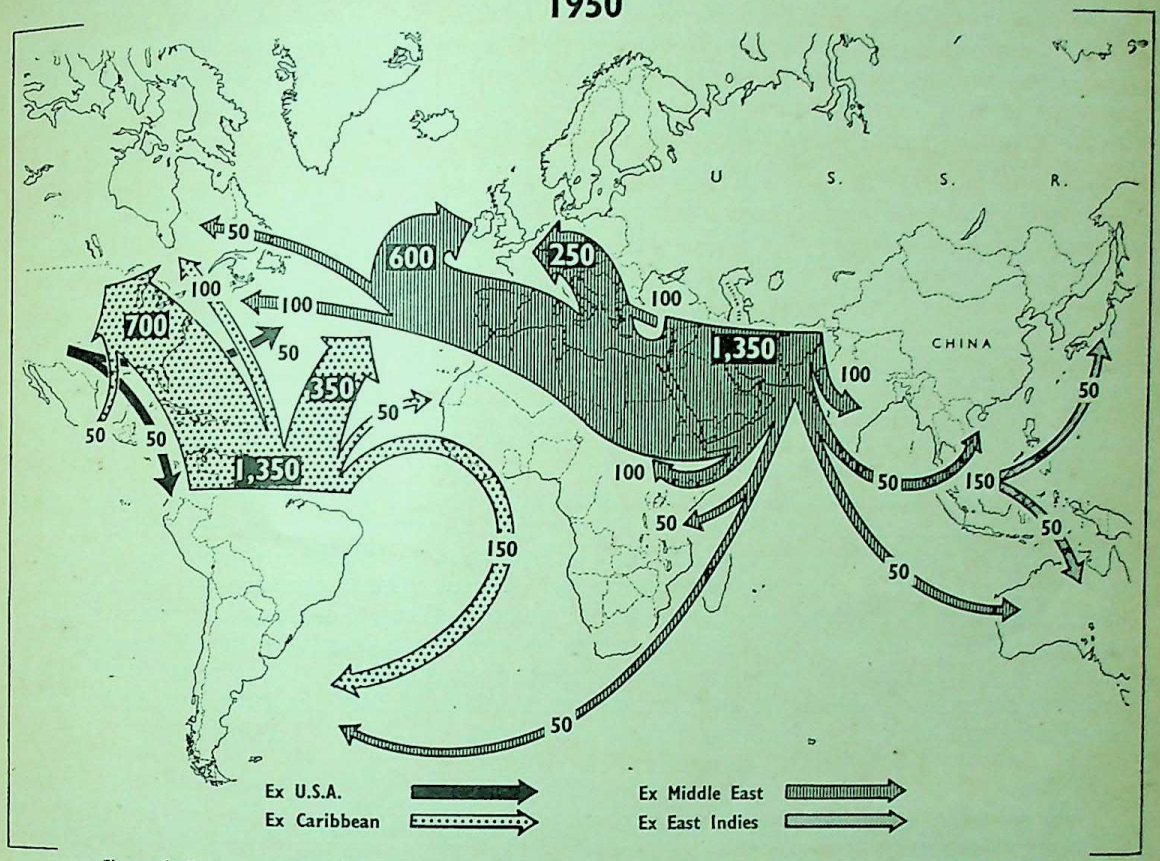
WORLD OIL MOVEMENTS—CRUDE OIL AND PRODUCTS

(EXCLUDING MOVEMENTS WITHIN NORTH AMERICA AND RUSSIAN SPHERE)

1950



Figures indicate quantities moved in 1,000's B/D. Individual movements are shown to the nearest 50,000 B/D.

Source.—Shell Petroleum Co.

generalized guidance can really be given on the particular methods best used in studying the consumption statistics of a particular area. The U.K. analysis in Section III should, however, provide a broad idea of the type of approach that is needed.

So far as the world as a whole is concerned, homogeneous statistics of actual consumption would naturally be desirable for any study of the industry, but unfortunately the character of the information available differs substantially country by country. Published estimates of domestic demand in most countries in the world are issued from time to time by the Bureau of Mines. They are based on production plus or minus the net of exports and imports, and though liable to the errors inherent in this type of computation, represent a valuable comprehensive indication of world consumption broken down into countries. If an attempt is made to develop this in greater detail, a lack of uniformity between countries in compiling and classifying their available statistics of consumption presents a considerable problem.

Within each country where statistics are available, a reasonable survey of consumption by product may be possible, but the collation of these figures for a world survey is hazardous in view of the absence of standard definitions. The greatest care has to be taken to guard against duplication or omission in the case, for instance, of re-exports, the re-running of processed oils and oil used for ships' bunkers, which is frequently delivered from bonded stock and may not therefore be included in the relevant import statistics. In certain areas, moreover, supplies earmarked for the armed forces are excluded from published data.

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One special factor which must be taken into account in effecting any comparison of consumption between countries is refinery consumption. Such quantities must clearly not be treated as domestic consumption, and must be excluded from total figures if effective comparison is to be made with countries where little or no refining takes place.

Certain attempts have been made from time to time to provide collated statistics of world oil consumption, and, in addition, special surveys made by one or other of the international oil companies are occasionally published in U.S. oil journals. If carefully used, these can be a useful source of information on consumption for further statistical analysis.

III. United Kingdom Statistics

The recent Petroleum Information Bureau publication, *U.K. Petroleum Industry Statistics relating to Consumption and Refinery Production*, represents a timely contribution to existing sources of information. Official statistics of the petroleum industry's distributive operations in the United Kingdom have hitherto been sketchy and inadequate. Although as long ago as 1861 the first import of oil into the United Kingdom was conveyed from across the Atlantic in the 224-ton brig "Elizabeth Watts", interest in United Kingdom petroleum statistics has, until comparatively recently, been limited to private organizations, the Government's concern with the industry having been mainly confined to its revenue-producing aspect. Most of the information required for official purposes has, accordingly, been recorded and published under the authority of H.M. Commissioners of Customs and Excise.

Within recent years certain factors have speeded the process of expansion and co-ordination of petroleum statistics. World War II involved a rigid Government control of petroleum, and the pooling of commercial interests which took place gave rise to a system which produced statistics covering the whole of United Kingdom operations. These statistics were far more accurate and comprehensive than anything which had been produced before. Following the return to competitive trading in the middle of 1948, arrangements were made jointly by the Government and the industry to maintain the war-time system of statistical analysis by co-operation between the individual companies, and it was these arrangements which enabled the Petroleum Information Bureau to introduce their publication in November, 1950.

Legal Definitions

Certain legal definitions of products have been established in the United Kingdom and, in view of the fact that a considerable proportion of the available statistics in this country emanate from official sources, it is of importance that such legal definitions should be recorded. They are, accordingly, set out in Appendix I.

Production

The indigenous sources of production of petroleum products in the U.K. are not of significance in relation to the total world production, and are relatively small in comparison with the U.K. consumption, but even so, they assume in some respects a considerable local importance.

The production of crude oil is minor, and the main indigenous output takes the form of products derived from shale and coal:

Table 10

U.K. Indigenous Production of Crude Petroleum and Products Derived from Shale Oil and Coal

(*Tons*)

	1920	1938	1950
Petroleum deposits—crude oil	400	100	43,500
Shale oil	224,000	125,400	113,000
Coal products—			
Low temperature carbonization	—	2,170	3,400
Hydrogenation	—	141,000	130,000
Coke ovens, gas works etc. (refined benzole)	80,000	214,510	250,000
Total coal products	80,000	357,680	383,400
Total indigenous production	304,400	483,180	539,900

Sources.—Ministry of Fuel and Power Statistical Digest except Refined Benzole in 1920, obtained from the National Benzole Association.

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The actual sources of indigenous production within the United Kingdom are as follows:

Petroleum Deposits

D'Arcy Exploration Co., Ltd.

Eakring, Duke's Wood, Kelham Hills, Caunton	in Nottinghamshire.
Formby	in Lancashire.
Hardstoft	in Derbyshire (not at present producing).
Nocton	in Lincolnshire (not at present producing).

Esso Petroleum Co., Ltd.

Dalkeith	in Midlothian.

Shale Oil

Scottish Oils, Ltd.

12 pits and mines near—

West Calder	in Midlothian.
Winchburgh	in West Lothian.

Coal Products

Low Temperature Carbonization

British Diesel Oil and Petrol Company	Bolsover, Derbyshire.

Hydrogenation

Imperial Chemical Industries	Billingham, County Durham.

Refining

Output of United Kingdom Refineries

With certain prominent exceptions, refining in the U.K. in 1938 tended to be limited to plant which had been designed primarily for the production of specialized products, such as bitumen and lubricating oil, and 80 per cent. of petroleum products required in the United Kingdom market were imported as finished products from overseas refineries. A considerable output of fuel oils automatically went hand in hand with the manufacture of these specialized products, but to a very large degree "topped crudes" (i.e., crude from which the lighter fractions had already been extracted) were imported for refinery treatment, and the output of motor spirit was consequently relatively small. In the post-war period, for reasons referred to in Section II, the oil companies have embarked on a large programme of refinery expansion which, when completed in 1953/54, will enable the demand for petroleum products in this country to be met almost entirely from home refineries.

A combination of the data set out in Table I and in Table IV of the Petroleum Information Bureau publication, *U.K. Petroleum Industry Statistics Relating to Consumption and Refinery Production*, provides an effective comparison between refinery production pre-war and in 1950:

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TABLE 11

U.K. Consumption and Refinery Production, 1938 and 1950

(*Tons*)

Products	1938			1950		
	Consumption	*Refinery Production*	%	*Consumption*	*Refinery Production*	%
Aviation spirit and motor spirit	4,942,875	316,531	6·4	5,477,162	1,477,955	27·0
Industrial spirits	38,366	2,585	6·7	80,667	3,401	4·2
White spirit	72,057	27,181	37·7	148,994	48,826	32·8
Kerosene	720,676	127,373	17·7	1,539,024	160,496	10·4
Gas/diesel and fuel oils (incl. derv fuel)	1,995,059[1]	1,021,939	51·2	6,371,894[1]	6,235,485	97·9
Lubricants	564,000	157,805	28·0	748,796	427,288	57·1
Paraffin wax and scale	48,121	11,843	24·6	43,177	15,563	36·0
Liquid gases	2,400	1,600	66·7	30,251	23,736	78·5
Bitumen	607,132	612,609	100·9	621,281	636,085	102·4
Total	8,990,686	2,279,466	25·4	15,061,246	9,028,835	59·9
Miscellaneous products and loss	—	112,256		215,525	254,917	118·3
Grand total	8,990,686	2,391,722	26·6	15,276,771	9,283,752	60·8

[1] Excluding supplies for ships' bunkers.

Source.—U.K. Petroleum Industry Statistics Relating to Consumption and Refinery Production.

Planned United Kingdom Refineries

Extensive progress has already been made on the refining projects in this country, and the following table records the location and planned capacities of the various plants in existence or under construction in the United Kingdom, taken from the Second Report on Co-ordination of Oil Refinery Expansion in the O.E.E.C. Countries, 1951.

TABLE 12

Annual Throughput of United Kingdom Refineries

(*Tons*)

Refineries	1952–3 *Estimated Crude Oil Throughput in Long Tons*
Shell—	
Stanlow	3,430,000
Shell Haven	2,250,000
Heysham	1,820,000
Ardrossan	150,000
Anglo-Iranian Oil Co.—	
Llandarcy	2,680,000
Kent (Shoreport—Isle of Grain)	2,000,000
Grangemouth	1,560,000
Pumpherston	170,000
Esso Petroleum Co.—	
Fawley	6,090,000
Vacuum—	
Coryton	420,000
Manchester Oil Refinery—	
Partington (Barton)	120,000
Berry Wiggins—	
Kingsnorth	60,000
Weaste	50,000
Lobitos—	
Ellesmere Port	150,000
William Briggs—	
Dundee	30,000
Total	20,980,000

Note.—The above figures are quoted in the O.E.E.C. report in metric tons and have been converted to long tons.

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Published statements of the companies concerned in some instances give different figures from those shown in the table. Thus the total current capacity at Stanlow and Shell Haven combined has been given as 6,750,000 tons; Grangemouth and Llandarcy are producing at the rate of 2,250,000 and 4,000,000 tons respectively, whilst the Isle of Grain refinery, which is not yet completed, is scheduled to be producing at the rate of 2,000,000 tons a year by mid-1952 and 4,000,000 tons a year by the end of that year. The ultimate capacity of some of these refineries may, of course, exceed the O.E.E.C. estimates for 1952-3 given above, Vacuum, for instance, having already published a figure of 850,000 tons.

Imports

In any market which is receiving a substantial proportion of its requirements from overseas, the nature, source and points of receipt of its imports will naturally be of considerable significance. Comprehensive data are available from the *Accounts Relating to the Trade and Navigation of the United Kingdom*, which, although only provisional on a month-by-month basis and therefore unsuitable for work requiring a high standard of accuracy, can be used to form a reliable picture on an annual basis:

TABLE 13

Imports of Petroleum into the U.K.

Country	1938			1950		
	Quantity			Quantity		
	Million Gallons	% of Total	Value (£'000)	Million Gallons	% of Total	Value (£'000)
U.S.A.	562·2	17·5	10,539·0	239·4	4·7	15,627·1
N.W.I.	1,076·3	33·6	14,639·7	1,010·9	19·9	40,833·8
Venezuela	138·9	4·3	1,135·0	382·5	7·5	16,029·2
Persia	626·8	19·6	8,242·1	1,261·0	24·8	45,260·8
Iraq	142·0	4·4	1,278·2	127·2	2·5	4,392·3
Saudi Arabia	—		—	278·6	5·5	8,114·1
Bahrein, Kuwait and Qatar	—		—	1,076·2	21·2	34,489·4
Trinidad	208·0	6·5	3,029·9	176·9	3·5	7,439·2
Mexico	54·3	1·7	739·1	26·4	0·5	1,050·8
Peru	21·9	0·7	243·3	37·9	0·7	1,446·2
Holland	—		—	282·0	5·6	10,277·5
France	—		—	94·4	1·9	4,100·8
U.S.S.R.	80·0	2·5	1,318·7	—		—
Roumania	93·4	2·9	1,295·7	—		—
Indonesia	23·8	0·7	573·4	7·6	0·1	336·1
Others	179·0	5·6	2,925·4	80·0	1·6	3,804·1
Total	3,206·6	100·0	45,959·5	5,081·0	100·0	193,201·4

Source.—Accounts Relating to the Trade and Navigation of the United Kingdom.

The significance of Middle East production so far as the U.K. is concerned is brought into sharp relief in Table 13. Persia, Iraq, Saudi Arabia and the Bahrein-Kuwait-Qatar regions bordering on the Persian Gulf were responsible in 1950 for 54·0 per cent. of the imports of the petroleum products in the U.K., compared with 24·0 per cent. in 1938, and, in addition, a large proportion of the 7·5 per cent. of finished products imported from the Dutch and French refineries would have been produced from Middle East crude. As the proportion of U.K. consumption met from home refineries tends to increase, so will the pattern presented by the table tend to change.

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The monthly *Accounts Relating to the Trade and Navigation of the United Kingdom* are consolidated and analysed in more detail in the *Annual Statements of Trade of the United Kingdom*, generally published in four volumes some two years after the period to which they relate, with a supplement every three years.

Imports of petroleum products, both of crude and finished products, figure largely in the trade of the major ports of the U.K., and detailed information on individual cargoes can be obtained from the Customs and Excise Authorities on payment of the requisite fee. An analysis by ports of discharge during a specimen period indicates the relative prominence of the main ports in this respect, while the application of these percentages to the total imports in 1950 gives a workable assessment of the annual quantities involved.

TABLE 14

United Kingdom : Analysis of Imports of Petroleum Products by Ports of Discharge

Port	*Percentage Allocation of Total Imports during July/December*, 1950	*Percentage in Col. 2 Applied to Annual Gallonage in Table 13 Above (Million Gallons)*
London	22·5	1,143
Southampton	7·6	386
Plymouth	0·5	25
Bristol	5·8	295
Swansea	15·6	793
Mersey	18·7	950
Heysham	9·4	478
Ardrossan	1·1	56
Glasgow	1·9	97
Grangemouth	4·1	208
Newcastle	3·0	152
Hull	9·4	478
Others	0.4	20
Total	100·0	5,081

Consumption

In the context of this paper, an analysis of consumption in this country would not only have the object of providing detailed guidance so far as the United Kingdom is concerned, but would serve also as an example of the approach required to a study of consumption in other markets. It should be appreciated, therefore, that some of the data referred to is made available owing to statutory requirements, and such data will not necessarily be readily available in other markets. Equally, of course, there are certain other markets (particularly the U.S.A., to which special reference is made in Section IV) where far more detailed information is available than in the United Kingdom.

Deliveries into Consumption

No proper appreciation of the nature of consumption of petroleum products in the United Kingdom is possible without carrying out first a broad examination of the trends since the beginning of the century. Authoritative statistics of this character are not available for the period 1900 to 1937, but if one is prepared to rely on estimates for these years, recorded by one of the larger distributing organizations on the basis of imports and other available data, and link these with figures published by the Ministry of Fuel and Power and the Petroleum Information Bureau, an effective picture can be obtained as follows:

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TABLE 15

United Kingdom : Inland Consumption of Petroleum Products

(*Tons*)

Year	*Motor, Aviation and Industrial Spirit*	*Kerosene (Burning Oil and Vaporizing Oil)*	*Derv Fuel*[1]	*Gas/Diesel and Fuel Oils*[2] *(Inland Trade)*	*Lubricating Oils*	*Bitumen*	*Other Products*[3]	*Total*
1900	—	870,000	—	—	165,000	—	—	1,035,000
1910	190,000	615,000	—	356,000	239,000	—	1,000	1,401,000
1921	850,000	536,000	—	726,000	342,000	44,000	88,000	2,586,000
1922	1,040,000	539,000	—	805,000	346,000	67,000	91,000	2,888,000
1923	1,207,000	572,000	—	924,000	333,000	146,000	95,000	3,277,000
1924	1,563,000	558,000	—	941,000	395,000	194,000	97,000	3,748,000
1925	1,765,000	683,000	—	956,000	405,000	200,000	103,000	4,112,000
1926	2,070,000	684,000	—	1,844,000	385,000	238,000	106,000	5,327,000
1927	2,304,000	744,000	—	1,125,000	430,000	282,000	109,000	4,994,000
1928	2,702,000	691,000	—	1,122,000	455,000	335,000	115,000	5,420,000
1929	2,971,000	722,000	—	1,243,000	471,000	353,000	108,000	5,868,000
1930	3,324,000	676,000	—	1,266,000	472,000	372,000	107,000	6,217,000
1931	3,468,000	707,000	3,000	1,335,000	453,000	400,000	107,000	6,473,000
1932	3,586,000	722,000	10,000	1,441,000	412,000	396,000	104,000	6,671,000
1933	3,822,000	741,000	33,000	1,479,000	441,000	440,000	103,000	7,059,000
1934	4,067,000	753,000	78,000	1,502,000	469,000	495,000	105,000	7,469,000
1935	4,293,000	737,000	142,000	1,521,000	502,000	506,000	115,000	7,816,000
1936	4,558,000	757,000	210,000	1,596,000	522,000	555,000	119,000	8,317,000
1937	4,734,000	774,000	291,000	1,592,000	564,000	591,000	127,000	8,673,000
1938	4,981,241	720,676	387,059	1,608,000	564,000	607,132	122,578	8,990,686
1939	4,815,000	787,000	453,000	1,649,000	581,000	621,000	130,000	9,036,000
1940	3,786,178	874,332	429,175	1,730,000	511,389	380,118	142,090	7,853,282
1941	4,432,698	943,850	466,934	1,838,000	641,302	348,180	152,177	8,823,141
1942	4,366,590	1,012,178	472,684	1,784,000	622,403	248,484	158,796	8,665,135
1943	5,068,915	1,066,662	452,040	1,723,000	586,256	177,395	146,384	9,220,652
1944	8,518,927	1,133,417	498,953	1,939,000	692,945	262,533	163,213	13,208,988
1945	5,991,796	1,263,396	511,551	1,877,000	546,455	242,793	165,261	10,598,252
1946	4,462,651	1,293,089	611,450	2,378,000	608,142	376,472	173,904	9,903,708
1947	4,894,164	1,496,520	701,002	3,841,000	659,260	423,872	200,421	12,216,239
1948	4,604,317	1,439,473	816,726	4,531,410	653,000	492,941	228,158	12,766,025
1949	5,023,806	1,525,202	924,350	4,782,657	714,274	545,262	324,176	13,839,727
1950	5,557,829	1,539,024	1,034,103	5,337,791	748,796	621,281	437,947	15,276,771

[1] Derv fuel is fuel used for diesel-engined road vehicles. Derv fuel consumption for 1928, 1929 and 1930 was 100 tons, 100 tons and 600 tons, respectively.

[2] Figures for gas, diesel and fuel oils include refinery consumption and an allowance for tar oils handled by the petroleum industry.

[3] Other products include white spirit, liquid gases and, from 1947, feedstock for petroleum chemical plants.

Sources.

1900–1937 Estimated.

1938–1950 { *Ministry of Fuel and Power Statistical Digest.*
U.K. Petroleum Industry Statistics Relating to Consumption and Refinery Production, published by the Petroleum Information Bureau.

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This table demonstrates the major trends and changes during the last 50 years and to aid its interpretation a list might be made of the particularly significant features, as follows:

(1) The early predominance of kerosene, mainly for paraffin lamps. In 1900 something like 80 per cent. of all petroleum imports were used for the paraffin lamp, of which there were some 10,000,000 in use.

(2) The acceleration in the development of motor spirit as a result of World War I. Great strides were made in the use of petrol engines for war purposes, with the result that at the end of the war a large number of men who had been in the Services had become familiar with the internal combustion engine. At the same time, the capacity of British industry to manufacture motor vehicles was greatly expanded, and the total number of motor vehicles in use rose from 390,000 in 1914 to 650,000 in 1920.

(3) The effect of vigorous competitive methods on the market for bitumen in the early twenties. These, coupled with substantial improvements in the bulk handling of the product, increased the demand from 44,000 tons in 1921 to nearly 200,000 tons in 1924, a period during which the total expenditure on the roads increased by only 17 per cent.

(4) The effect of the general strike in 1926 on the consumption of gas, diesel and fuel oils. The acute shortage of coal gave rise to a heavy short-term demand from consumers who had never before contemplated using liquid fuel, and the total figure for 1926 thus attained was not surpassed until 18 years later.

(5) The reverse effect of the general strike on the consumption of lubricating oil, resulting, of course, from the overall decline in industrial activity.

(6) The relative stability in consumption of kerosene over the period 1925 to 1938. In fact, the early stages of the development of mechanized farming giving rise to a steady increase in the use of vaporizing oil masked the fall in the demand for burning oil which followed the extension in availability of electricity and gas.

(7) The introduction of the compression ignition engine and the appearance of diesel oil as a motor fuel (derv fuel). The diesel engine made its first appearance in a commercial vehicle in the United Kingdom in 1928, and between 1934 and 1938 the number of diesel vehicles had approximately quadrupled.

The above items refer in the main to the years prior to World War II. A more detailed examination and analysis of the years since 1938 are now made possible by the issue of the Petroleum Information Bureau publication, *U.K. Petroleum Industry Statistics Relating to Consumption and Refinery Production*. These statistics have, moreover, been repeated up to 1949 in the *Ministry of Fuel and Power Statistical Digest*, 1948 and 1949, in association with figures of the consumption of petroleum products during the years 1939 to 1948, when the marketing interests of the individual companies were merged in the Petroleum Board.

Between 1938 and 1950 consumption of all kinds of petroleum products in the United Kingdom rose from 8,990,686 tons to 15,276,771 tons, and at the same time a significant change in the pattern of consumption of the different products took place. The following notes pinpointing the main features of this change are intended to be examined in conjunction with Tables I and III of the *U.K. Petroleum Industry Statistics Relating to Consumption and Refinery Production:*

(a) *Motor Spirit*

One of the chief changes thrown into prominence was the reduced proportion of the total consumption of petroleum products attributable to motor spirit. Pre-war this accounted for over half the inland consumption of the United Kingdom, whereas in 1950 it amounted to only one-third, a proportional decline which was accentuated, of course, by the restriction placed on the consumption of motor spirit by rationing. Rationing, however, ended in the middle of 1950, and the resulting increase of some 450,000 tons per annum in the rate of consumption raised the 1950 figure to 365,000 tons above the 1938 level.

Of the 1950 consumption 65 per cent. was supplied through retailers (dealers) and 35 per cent. direct to commercial users, contrasting with a ratio of 58 per cent. to 42 per cent. pre-war. This change arose mainly because of the substitution of the use of derv fuel for a material pro-

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portion of the motor spirit previously supplied direct to commercial consumers, accentuated by the fact that in a number of cases storage facilities owned by commercial users in 1938 were taken out of use during the war.

(b) *Gas, Diesel and Fuel Oils (Inland)*

A second noteworthy feature was the more than threefold expansion in the use of gas, diesel and fuel oils for inland consumption. The initial impetus to this expansion, which took place following 1945, arose in large measure from the Government's coal-oil conversion campaign, introduced in 1946 and accelerated as a result of the serious fuel situation which arose in the early months of 1947. The campaign, which unfortunately involved the transfer to oil of many processes which were by no means economical, was curtailed at the end of 1947, but further substantial increases have since taken place in industries where the use of oil in contrast to the use of other fuel has real economic advantages.

(c) *Aviation Spirit*

The level of demand for aviation spirit rose from 112,549 tons in 1938 to 287,506 tons in 1949, but declined by 5,517 tons in 1950. This decrease resulted from the rapidly increasing use of the gas turbine engine, using aviation turbine fuel (at present mainly a type of kerosene) in place of aviation spirit.

(d) *Industrial Spirits*

Industrial spirits (including industrial benzole) showed an increase in consumption from 38,366 tons in 1938 to 80,667 tons in 1950. This group of distillates, consisting mainly of special boiling-point spirits (S.B.P's) and rubber solvents, has an increasingly wide range of uses in industrial processes. The increase shown in these products compares with the increase in industrial production as a whole (something like 33 per cent. between 1938 and 1950, according to the *United Nations Monthly Bulletin of Statistics*), and particularly that of the principal rubber-consuming industries, such as the motor, cycle and aircraft group, which showed an increase between 1935 and 1950 of 85 per cent.*

(e) *White Spirit*

White spirit consumption, at 148,994 tons in 1950, had slightly more than doubled since before the war. Two-thirds of the total was used in the paint and varnish industry, and the expansion has been largely due to the sustained demand for paints, both for domestic and industrial purposes. Dry-cleaning, one of the other chief markets for white spirit, received a fillip on account of the scarcity and expense of new clothes.

(f) *Kerosene*

In the kerosene group, which showed an increase in offtake from 720,676 tons in 1938 to 1,539,024 tons in 1950, the chief contributing factors were the remarkable rise in the number of vaporizing oil tractors in use between the two years, and the recent very sharp rise in demand for aviation turbine fuel, which was non-existent in 1938.

In total, the number of tractors in the United Kingdom increased from 54,000 in 1938 to some 385,000 (including some 45,000 small market-garden types) in 1950. Of these, 35,500 (65 per cent.) and 270,000 (70 per cent.) respectively used vaporizing oil as a fuel. While in line with the world-wide movement towards mechanization in agriculture, the United Kingdom was unique in the extent of the increase† and in the overwhelming preponderance of vaporizing oil types.

With the spread of electricity, gas and bottled gas, burning oil consumption has naturally shown a tendency to decrease from the pre-war level, although the obstacles to rural electrification, coal shortages and widespread power cuts have led recently to a considerable revival in the use of this product.

(g) *Derv Fuel*

At the Fourth World Power Conference in London in July, 1950, the chief engineer of the Rolls-Royce motor car division read a paper in which he stated that diesel engines were established

* "London and Cambridge Economic Service Index of Industrial Production".

† *Farm Mechanization*, September, 1950: "Food and Agriculture Organization of the United Nations", Washington.

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as the most economical prime movers in the transport field. This conviction is one way of explaining the increase from 387,059 tons in 1938 to 1,034,103 tons in 1950 in consumption of derv fuel, which bears a name derived from the initials of the words "Diesel Engined Road Vehicles". Considerable numbers of the larger municipal corporations have been abandoning trams, in nearly all cases in favour of diesel-engined buses. London Transport Executive, for example, by the end of 1950 was not using a single petrol-engined bus, and was in process of replacing its remaining trams with diesel buses. Another factor is the rise, between the years, in the number of passenger journeys. The Annual Reports of the Licensing Authorities for Public Service Vehicles show that this figure more than doubled between 1938 and 1949.* The heavier goods vehicles have also joined in this process of substitution of the diesel for the petrol engine, having more than trebled in number during this period in the United Kingdom.

(h) *Lubricating Oils and Greases*

Most petroleum products have diverse uses, but lubricants and greases enter into every phase of industrial activity. It has even been suggested that a useful index of industrial activity as a whole could be calculated from figures of lubricants consumption. In this connection it is interesting to notice that consumption increased from 564,000 tons in 1938 to 748,796 tons in 1950 or by nearly 33 per cent., which exactly corresponds with the increase in the index of industrial production for the United Kingdom given in the *United Nations Monthly Bulletin of Statistics* between these years.

In practice there are many activities in regard to which the fuel consumption but not the lubricating oil consumption is known. In such cases lubricating oil/fuel ratios are often used as a rough guide to lubricants consumption. Thus for motor spirit the ratio in the United Kingdom is generally taken as 3 per cent. and for vaporizing oil 4 per cent., but these need to be constantly reviewed in case new factors have caused a substantial variation. A particular example of such a variation is provided by statistics published by the United States Department of Agriculture. These show a fall in the ratio in the case of agricultural tractors from 6½ per cent. in 1920 to just over 2 per cent. in 1947, a decline which was mainly attributed to improvements in tractor engine design, increased use of filters and wider use of petrol in place of other heavier fuels.

(i) *Oil Used for Ships' Bunkers*

In broad terms oil consumed by marine craft engaged in river and costal traffic is regarded as domestic consumption and included in the "Gas, diesel and fuel oil (Inland)" figure recorded in *U.K. Petroleum Industry Statistics Relating to Consumption and Refinery Production.* Oil consumed in ocean-going craft is normally referred to as "Bunker Trade"; a figure quoted as "oil fuel shipped for the use of consumers, etc., engaged in the foreign trade (including fishing vessels)" is published in the *Accounts Relating to the Trade and Navigation of the United Kingdom,* and recorded annually in the *Ministry of Fuel and Power Statistical Digest* under the heading "Oil fuel for bunkers." It has to be borne in mind, however, that these figures are not precisely complementary to those recording the inland trade in gas, diesel and fuel oil, published by the Petroleum Information Bureau.

Seasonal Variations.

There is a marked variation in the seasonal consumption of the different petroleum products, which may be simply demonstrated by a table of index numbers relating actual deliveries each month in 1950 to the calendar monthly proportion of the year's total. This method does not, of course, give an exact statistical result, as it fails to separate the seasonal movement from the trend, but it does not in practice distort the pattern unduly, and the following table reproduces adequately the effect of seasonal influences upon consumption.

* Basic Road Statistics, Great Britain, 1950. British Road Federation, London.

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TABLE 16

United Kingdom : Consumption of Petroleum Products
(Index Numbers : Monthly Average for Each Product—100)

Month	*Motor Spirit*	*Derv Fuel*	*Burning Oil*	*Vaporizing Oil*	*Gas, Diesel and Fuel Oils*
January	86·4	92·1	135·9	86·5	109·9
February	84·0	87·0	116·9	57·5	103·0
March	97·2	99·1	111·7	154·5	111·2
April	97·2	90·0	91·1	124·8	89·3
May	103·2	106·0	83·2	105·5	98·9
June	105·6	101·2	65·8	93·4	82·7
July	108·0	103·8	64·7	95·6	79·0
August	110·4	108·9	73·9	111·6	83·3
September	108·0	106·5	82·8	105·2	92·8
October	103·2	105·2	92·5	127·0	109·3
November	97·2	103·5	118·7	80·9	118·1
December	99·6	96·6	163·0	57·6	122·6

Note.—Based on 1950 figures except for motor spirit. These could not be used owing to the change in the rates of consumption resulting from derationing during that year.

A study of such data needs frequently to be undertaken, since the variations in consumption which take place have a direct bearing on short-term problems of supply, the forecasting of demand and on distribution. Under rationing the monthly consumption of motor spirit was to a great extent levelled out, but one of the consequences of derationing of motor fuel has been the reappearance of peak demands around holiday periods, with yearly variations according to the incidence of public holidays and the suitability of weather conditions.

The peak in August for motor spirit is normal, subject to the incidence of the August Bank Holiday week-end. If this falls in the first two or three days of August, so that the stocking up by dealers takes place in the last few days of July, this normally results in a higher figure in July than in August.

The monthly consumption of burning oil is, of course, very sensitive to changes in temperature, and even a relatively brief period below freezing point can give rise to a formidable increase in the burning oil consumption. The figures shown are not entirely representative of the normal year. The colder weather was experienced towards the end of 1950 much earlier than is usual, and the material increase shown in the above figures in November and December is usually delayed at least until the last week or two of December. The relationship between consumption in the last quarter of the year and the first quarter of the year is normally more like 0·9 to 1 than 1·03 to 1 as shown in the table.

Vaporizing oil is equally sensitive to weather conditions, particularly in the early part of the year, but in this case the overriding factor is the effect of those weather conditions on the state of the ground. The most serious delaying factor is an extensive spell of ice and snow, which not only prevent agricultural operations in themselves, but also give rise to a serious period of inactivity following the thaw as a result of the inevitable floods. 1950 was, on the whole, a fairly normal year so far as the relationship of monthly consumption was concerned, and it is interesting to compare the indices for that year with those for 1947 (probably the worst spring in modern farming history) and for 1951:

TABLE 17

Monthly Consumption of Vaporizing Oil
(Index Numbers : Monthly Average = 100)

	1947	1950	1951
January	70·7	86·5	71·6
February	41·0	57·5	65·6
March	64·5	154·5	88·5
April	178·8	124·9	174·1
May	148·5	105·5	128·6
June	89·6	93·5	97·6
July	90·4	95·7	104·8
August	115·6	111·6	90·3
September	114·2	105·3	101·9
October	121·5	127·0	135·5
November	85·4	80·9	70·6
December	79·8	57·1	71·0

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End-Uses

A focus on the consumption of individual products leads to a consideration of "End-Uses". The main published end-use analysis is in respect of Gas/Diesel and Fuel Oils—inland trade, given in *U.K. Petroleum Industry Statistics Relating to Consumption and Refinery Production*, but the *Ministry of Fuel and Power Digest*, 1948 and 1949 also gives some analysis of motor spirit and derv fuel consumption by class of consumer.

(a) *Motor Spirit*

The Ministry of Fuel and Power analysis for 1949, after spreading the Northern Ireland figure between the categories, may be compared with reliable estimates for 1938 and 1950 to bring into relief a number of noteworthy developments:

TABLE 18

United Kingdom : Motor Spirit—End-Uses

(*Thousand Tons*)

	1938	1949	1950
Cars and motor cycles . .	2,260	1,526	1,915
Public service vehicles . .	450	190	180
Goods vehicles . . .	1,650	1,975	2,100
Taxis and hired cars . .	100	110	110
Industrial uses . . .	122	220	210
Agriculture	70	260	280
Government departments, etc.	138	325	335
Miscellaneous . . .	40	65	65
Total . . .	4,830	4,671	5,195

The table shows the effect of rationing on the car consumption, which rose sharply after derationing in May, 1950. The decline in consumption by public service vehicles reflects the large-scale change-over to derv fuel, while the increased offtake by goods vehicles is accounted for by the doubling between 1938 and 1950 of "C" licensed vehicles, nearly all of which are under 3-tons unladen weight and therefore run on motor spirit. Agricultural offtake was some four times as great in 1950 as in 1938, due to greatly increased mechanization in all branches of farming. The number of farm tractors running on motor spirit rose from 9,000 in 1938 to 53,000 in 1950, and motor spirit is also used in starting vaporizing oil tractors, which showed an even greater proportionate increase from some 35,000 to 270,000 during the same period.

(b) *Gas, Diesel and Fuel Oil*

The deliveries into consumption of gas, diesel and fuel oils are divided into two main groups—Burning and Power—and development in these two groups can be examined in Table 3 in the *U.K. Petroleum Industry Statistics Relating to Consumption and Refinery Production*. The Government exercised complete control of the former until November, 1950, but the Power group, on the other hand, has been free to develop and the expansion in these uses was largely due to economic factors.

The conversion of steam trawlers from coal to oil is mainly responsible for the increase in marine craft. The bulk of the relatively large quantity of oil used on the railways in 1948 represents deliveries to the few locomotives (out of the very large programme projected) that were converted from coal to oil. This programme was later abandoned, and the lower quantity shown for 1949 mainly represents deliveries to diesel shunting locomotives, which are now standard equipment on British Railways. This type of shunting locomotive has also gained a secure hold in private sidings, but the use of diesel traction for mainline passenger and freight traffic has, unlike other countries, not yet been developed to any appreciable extent in the United Kingdom.

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Stationary oil engines are a relatively stable market, controlled mainly by economic factors. Mobile diesel engines, on the other hand, show a very large expansion, due in part to the greater use since the war of heavy earth-moving machinery in both general contracting and open-cast coal production, and the considerable expansion in Agricultural Power Units reflects the increasing popularity of the diesel tractor.

The officially sponsored coal-oil conversion programme of 1946–47 was mainly responsible for initiating the very large increases shown in glass, steel manufacture, industrial furnaces and steam raising. A considerable portion of the country's steel production is now made in oil-fired open hearth furnaces, a development entirely new in this country since 1938, and the faster production rate obtainable from oil-fired furnaces has played a not insignificant part in the steel industry's excellent production record of recent years.

The considerable increase in the oil industry's uses is a reflection of the greater amount of home refining now being carried out, and can be expected to increase as the balance of the new refinery programme comes into production.

The remaining item calling for comment is the greater use of oil in the gas industry, which reached an all-time high record of 680,000 tons in 1947. Although oil is normally employed in gas-making to meet peak demands, the very large increase shown is to some extent caused by prevailing difficulties in the production of gas coal.

Duty

Duty on motor spirit at the rate of 3*d.* per gallon was first introduced in the 1909 Finance Act. On January 1st, 1921, it was abolished and horse-power taxation substituted.

It was not until April 25th, 1928 that a tax of 4*d.* per gallon was re-imposed on all imported light hydrocarbon oils, and thereafter there were progressive increases up to a level in 1951 of 1*s.* 10½*d.* per gallon; simultaneously with the increase to 1*s.* 6*d.* in 1950, an excise duty of 9*d.* per gallon was levied on indigenous oils, which was increased in 1951 to 1*s.* 1½*d.*

In April, 1933, the first levy on heavy oil used in road vehicles and on lubricating oil was imposed at 1*d.* per gallon; the duty on heavy oil for road vehicles was, of course, thereafter increased to the same figure as for light hydrocarbon oil, i.e., 1*s.* 10½*d.* per gallon. April, 1933, was also significant for the introduction of duty of 1*d.* per gallon on kerosene, gas and fuel oils, but these products were exempted from duty in 1947.

Table 19 provides a historical review of the duty as applied to the major petroleum products.

TABLE 19

Petroleum Duties—U.K.

(*Pence per Gallon*)

Effective Date	*Motor Spirit (incl. Aviation Spirit)*	*Spirit other than Motor Spirit*	*Heavy Oil used in Road Vehicles*	*Lubricating Oil*	*Kerosene*	*Gas and Fuel Oils*
April, 1909	3*d.*	—	—	—	—	—
September, 1915	6*d.*	—	—	—	—	—
January, 1921	Repealed	—	—	—	—	—
April, 1928	4*d.*	4*d.*	—	—	—	—
April, 1931	6*d.*	6*d.*	—	—	—	—
September, 1931	8*d.*	8*d.*	—	—	—	—
April, 1933	8*d.*	8*d.*	1*d.*	1*d.*	1*d.*	1*d.*
August, 1935	8*d.*	8*d.*	8*d.*	1*d.*	1*d.*	1*d.*
April, 1938	9*d.*	9*d.*	9*d.*	1*d.*	1*d.*	1*d.*
April, 1947	9*d.*	9*d.*	9*d.*	1*d.*	1*d.*	Repealed[1]
August, 1947	9*d.*	9*d.*	9*d.*	1*d.*	Repealed	—
April, 1950	1*s.* 6*d.*	1*s.* 6*d.*	1*s.* 6*d.*	1*d.*	—	—
April, 1951	1*s.* 10½*d.*	1*s.* 10½*d.*	1*s.* 10½*d.*	1*d.*	—	—

[1] Subsidy of 1*d.* per gallon granted on gas and fuel oils from October 1st, 1946.

Source.—Annual Reports of Commissioners of Customs and Excise.

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An indication of the cumulative yield on petroleum duty is illustrated by Table 20:

TABLE 20

United Kingdom Petroleum Duties : Main Receipts

(£'000's)

Product	*Actual Receipts*															
	April, 1909[1] *to Dec. 1920*	*April, 1928*[2] *to March, 1933*	*April, 1933*[3] *to March, 1938*	*Year Ended March 31st* 1939	1940	1941	1942	1943	1944	1945	1946	1947	1948[4]	1949	1950	1951[5]	*Total*
Motor spirit	17,050	106,323	203,165	50,911	46,218	39,725	46,372	47,649	75,809	101,467	56,255	45,467	48,068	47,872	51,589	120,461	1,104,401
Spirit other than motor spirit	—	1,788	3,428	915	1,092	1,044	1,279	1,153	1,252	1,358	1,391	1,501	1,666	1,725	1,990	3,400	24,982
Heavy oil used in road vehicles	—	—	4,796	3,427	3,727	3,789	3,859	3,928	3,966	4,570	4,524	5,535	6,574	7,515	8,631	19,000	83,841
Kerosene	—	—	3,997	848	946	1,003	1,053	1,186	1,238	1,384	1,379	1,495	738	—	—	—	15,267
Lubricating oil	—	—	2,087	429	544	529	652	636	656	788	537	480	558	510	598	700	9,704
Gas oil	—	—	1,448	295	368	414	493	450	942	1,046	1,039	1,337	59	—	—	—	7,891
Fuel oil	—	—	5,492	1,160	1,134	969	933	789	339	586	309	836	61	—	—	—	12,608
Other sorts	—	—	169	25	24	21	15	5	5	9	11	12	10	5	10	10	331
Total	17,050	108,111	224,582	58,010	54,053	47,494	54,656	55,796	84,207	111,208	65,445	56,663	57,734	57,627	62,818	143,571	1,259,025

[1] Duty abolished as from January 1st, 1921 (and horse-power taxation substituted).

[2] Duty reimposed as from April 25th, 1928.

[3] Duty imposed on "heavy oils" as from April 25th, 1933.

[4] Duty on gas and fuel oils legally abolished April 15th, 1947. It was in practice abolished on October 1st, 1946 by the granting of a temporary subsidy of 1d. per gallon until the 1947 Budget. Duty on kerosene abolished on August 31st, 1947.

[5] Duty increased from 9*d.* to 1*s.* 6*d.* per gallon as from April 18th, 1950.

Sources.—1909–50 *Actual Receipts—Annual Reports of Customs and Excise.*
1951 *Based on Receipts (Provisional)—Financial Statement (1951–52), April 10th, 1951.*

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Other Relevant U.K. Statistics

(a) *Exports and Re-exports*

Exports and re-exports of petroleum from the U.K., except to Southern Ireland and to such areas as the Canaries, Channel Islands and the Faeroes, have in the main been limited to specialized products such as lubricating oil and bitumen, although in recent months exports of fuel and diesel oil in particular have increased substantially. The relevant statistics are contained in the *Accounts Relating to the Trade and Navigation of the United Kingdom* (subsequently consolidated in the *Annual Statements of Trade of the United Kingdom*—see p. 550) and in the recent series of Reports on Overseas Trade.

(b) *Motor Vehicles*

Of all official statistics bearing on end-uses of petroleum these are undoubtedly the most comprehensive, and reference should be made to an earlier paper in this series by C. V. Ford on "Statistics Relating to the British Motor Industry". At September 30th of each year a census is taken and published by the Ministry of Transport of all vehicles for which licences were current during the preceding quarter, and quarterly returns are also given of all new registrations. Monthly figures of new registrations, obtained from the Ministry of Transport, are published in the *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders, which also gives a limited analysis of numbers in use at quarterly intervals. Tables giving valuable historical summaries dating back to 1904 are contained in *Basic Road Statistics* published by the British Road Federation annually. More detailed facts about public service vehicles and goods vehicles are given in the *Summary of Annual Reports of the Licensing Authorities* (published separately for these two classes of vehicles), and since the formation of the British Transport Commission the monthly publication *Transport Statistics* shows the fleets of various Executives of the Commission at the end of each period, and the fuel consumption, which is summarized annually in the Report and Accounts of the Commission.

(c) *Aircraft*

Apart from the summaries given in the *Monthly Digest of Statistics* and the *Annual Abstract of Statistics*, further analysis of aircraft in use, as between charter companies, airlines, etc., is shown in the annual reports of the Ministry of Civil Aviation. The Air Registration Board also gives much information on this subject.

(d) *Agricultural Tractors*

Censuses of agricultural machinery and implements are taken biennially by agricultural departments. Monthly figures of production both for export and home markets are published in the *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders. It is thus possible to estimate the numbers in use in the intervening years by adding home market production to the previous census figure and allowing a percentage wastage, based upon previous years. New registrations of the 5*s*. class of agricultural tractors (now the £2 class under the Finance Act, 1950), containing the bulk of those used primarily on the land and whose road use is restricted, are given monthly in the *Monthly Statistical Review*, analysed roughly by type of fuel—light or heavy oil—but there is, as yet, no analysis of the heavy oil class between diesel and kerosene.

Conversion Factors

As explained earlier on, world petroleum statistics are measured in a number of different ways. Those relating to the U.K. are generally expressed either in Imperial gallons (which are convenient units for pricing and taxation purposes as well as being more easily recognizable by the average consumer) or in English, or long, tons. The use of both units in the U.K. necessitates the computation of standard conversion factors for translating the one measure into the other. These factors have been published in the booklet of *U.K. Petroleum Industry Statistics* and relate, of course, to averages over the whole volume of supply, and would not necessarily be applicable to individual supplies from a particular source. These factors are subject to revision from time to time, as changes in, for instance, refinery technique alter the specific gravities of the various

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products and the problem of allowing for a comparison of, say, tons made up of differing numbers of gallons is a real one. Such changes are illustrated in the following table:

TABLE 21

Petroleum Conversion Factors

(Imperial Gallons per Long Ton)

	1938	1950	1951
Aviation spirit	300	307	315
Industrial spirits, Distillation benzine, Motor spirit (excl. benzole)	300	303	310
Motor spirit (incl. benzole)	300	300	310
Benzole	255	255	255
White spirit	280	284	284
Kerosene—All grades	276	276	276
Burning oil	280	280	280
Vaporizing oil	280	272	272
Gas oil	264	264	267
Derv fuel	267		
Marine gas oil, Diesel oil	259	259	259
Marine diesel oil	250	250	250
Light fuel oil	242	240	240
Heavy fuel oil (at 60° F.)	235	237	237
Marine fuel oil (at 60° F.)	230	230	230
Lubricating oil—white oils	255	255	255
—others	245	245	245
Bitumen	216	216	216

IV. U.S.A. STATISTICS

Owing to the special characteristics of the United States in regard to statistical analysis, it would be misleading to conclude this paper without particular reference to these characteristics and to their significance in regard to a study of petroleum statistics throughout the world. The special characteristics arise mainly from one of two causes:

1. That because of the very large proportion of production which arises in the U.S.A. and of the very large share of the world production which is consumed in the U.S.A. it is in many cases found to be essential to consider the U.S. position separately from that of the rest of the world.

2. That statistical information available in the U.S.A. concerning petroleum operations is generally much more complete and reliable than in the rest of the world.

World-wide Impact of U.S.A.

The size of the U.S. petroleum industry is such that operations in the rest of the world are apt to be dwarfed in comparison; for example, the domestic consumption of petroleum products in the U.S.A. in 1950 was nearly twice that of the world outside. In order, therefore, properly to distinguish trends in the world outside the U.S.A., it is often desirable to consider the U.S.A. more in terms of the petroleum imports from or exports to the rest of the world, which can be thus examined without the overwhelming additions of U.S. domestic production and consumption. Imports and exports, although only marginal to the U.S. domestic petroleum industry, can be of critical importance to the outside world, and the trend in the import/export balance is of greater interest, since in 1947 the U.S.A. became a net importer, as is shown in the following table:

TABLE 22

U.S.A. Imports and Exports : Crude Oil and Refined Products

(Thousands of Barrels per Day)

	Imports	*Exports*	*Net Import*	*Net Export*
1939	162	518	—	356
1946	377	420	—	43
1947	437	451	—	14
1948	514	368	146	—
1949	645	327	318	—
1950	847	304	543	—

Source.—U.S. Bureau of Mines

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Sources of Statistical Data

General

Reference has been made in Section II of this paper to various sources in the U.S.A. of individual statistics relating to production, refining and consumption; there are two sources, one official and the other industry-sponsored, which provide a complete series of data. The foremost official source is the Bureau of Mines—a branch of the U.S. Department of the Interior—which publishes a variety of statements, including the *Monthly Petroleum Statement*, covering a wide range of the industry's operations. The predominant unofficial source, the American Petroleum Institute (A.P.I.), is an organization formed and run by the petroleum industry. This body publishes a great deal of authoritative data which is complementary to that of the Bureau of Mines.

Departments other than the Bureau of Mines, for example, the Department of Commerce, publish certain statistics, but these are generally of a specialized nature. Similarly, there are a number of journals outside the Government sphere which issue both regular and intermittent series, also tending, however, to be of a specialist character.

For many categories of statistics, the continental U.S.A. is divided into five districts known as P.A.W.* districts. These five districts, numbered from 1 to 5, broadly comprise the five natural geographical subdivisions of the petroleum industry; the Atlantic Coast States, the Mid Continent and Mid West, the U.S. Gulf States, the Rocky Mountain States, and the States of the Pacific Coast.

In addition to the statistics of the major aspects of petroleum operations, which are similar in interpretation to, though often of better quality than, those for the rest of the world, there are a number of series published which are of peculiar importance in U.S. oil operations. Before examining these in more detail it is perhaps advisable to warn the student that the very elaboration and detail of U.S. statistics have certain drawbacks. Data for the same operations are often available from more than one source, and problems of reconciliation exist which require careful treatment.

Imports and Exports

Statistics of imports and exports are published for the continental U.S.A. in the Bureau of Mines monthly statement divided into crude oil and refined products. Weekly figures are published by the A.P.I. for the same area, which, though liable to extreme fluctuations, are sufficiently accurate when averaged over a period to give an indication of the general trend. A parallel series is published by the Bureau of Census, but this includes the data for the non-contiguous territories (Alaska, Hawaii, etc.). The Bureau of Census figures, though not strictly comparable to the Bureau of Mines data, have the advantage of being broken down into customs districts and major ports; imports are given by country of origin and exports by destination, although destinations are not always reliable owing to reshipments and changes *en route*.

Transportation

Reference has already been made in the World Section to the statistics of ocean-going tankers, and it is not proposed to deal separately with them here; there is, however, one aspect of tanker operations which is peculiar to the U.S.A. In the rest of the world ocean tankers are used mainly for inter-continental traffic. In the U.S.A., however, ocean tankers are used to a great extent in coastal movements, on the Pacific Coast and between the Texas Gulf and the East Coast states. Any analysis of international tanker operations must therefore take account of the extent to which the U.S. fleet will be engaged in coastal movements.

Pipelines are used to a much greater extent in the U.S.A. than in the rest of the world and this is reflected in the abundance of information available. Not only is there the information published in trade journals on pipeline capacities and construction as for elsewhere, but in addition regular series are published giving figures of pipeline throughputs. A summary of monthly crude oil movements by pipeline is included in the Bureau of Mines *Crude Petroleum Report by Refineries*, for example, and periodical reports of the operations of the major inter-state lines also appear in the various journals.

* P.A.W. refers to the Petroleum Administration for War, which was a special agency constituted during the recent war to supervise the industry's operations.

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Refinery Operations

Intake of refineries, or crude runs to stills, as it is usually termed, is reported in the *Monthly Petroleum Statement*. Total intake is broken down into "Domestic" and "Foreign" crude runs, and this facilitates, *inter alia*, a detailed examination of the level of stocks which are similarly classified and which are considered in greater detail below. The weekly figures of crude runs are, as for production, given in the A.P.I. weekly statistical report.

Refinery out-turn is reported in detail in the Bureau of Mines monthly statement: the production of the various products in broad grades is shown for each district. The A.P.I. weekly statement, while not entering into the same detail, gives the out-turn of the major products by P.A.W. districts.

The following table, taken from one issue of the A.P.I. weekly report, illustrates the scope of the figures, and shows the crude runs and refinery out-turn for one week. It should be noticed that the crude runs are given as a daily average, the product out-turn as a weekly total.

TABLE 23

Crude Oil Runs and Production of Major Refined Products, Week Ended 2.vi 51

District	*Crude Runs (1,000 B/D)*	*Production in 1,000's Barrels*			
		Gasolene	*Kerosene*	*Distillate Fuel*	*Residual Fuel*
East Coast	1,070	2,550	378	1,482	1,495
Appala.—Dist. 1	110	338	45	91	77
,, —Dist. 2	83	272	28	48	83
Ind.—Ill.—Ky.	1,248	4,639	530	1,238	1,231
Okla.—Kans.—Mo.	482	1,839	118	719	410
Inland Texas	243	1,084	69	331	286
Texas Gulf Coast	1,576	4,827	784	2,079	1,811
La. Gulf Coast	479	1,622	195	945	412
North La. Ark.	79	231	53	140	60
Rocky Mts.—N. Mexico	14	54	—	20	20
,, ,, —Other	219	756	16	276	333
California	998	2,874	101	925	2,711
	6,601	21,086	2,317	8,294	8,929

Source.—American Petroleum Institute Statistical Bulletin.

Both the Bureau of Mines and the A.P.I. statements are based on actual returns from refiners, and the figures, covering well over 90 per cent. of the refineries in operation, are adjusted to give a reliable indication of the trend of refinery operations as a whole.

Stocks

A field in which the U.S.A. is almost unique is in the publication of data regarding stocks. Crude oil stocks are reported by the Bureau of Mines in the monthly statement and in a weekly statement. Stocks of major refined products are published in the Bureau of Mines monthly statement by districts, and similar information is given in the A.P.I. weekly report. Such information is particularly valuable to the industry in the case of products with a marked seasonal variation, such as residual fuel oil, since it facilitates recognition of impending shortages in winter and inadequate stock build-up in summer.

Supply and Demand

Information available regarding consumption in the U.S.A. conforms to the same high standard as that covering other spheres, and thus it is possible to establish a reconciliation of supply and demand data in a way which cannot easily be effected from published information relating to the rest of the world. The Bureau of Mines monthly statements not only give the relevant statistics for the different operations of the oil industry, but also present them in the form of a balance between consumption and production. An integrated presentation of most aspects of the oil industry is therefore made possible, and the statistician intending to work with oil data for the rest of the world will often be assisted by reference to the framework of the more complete material available for the U.S.A.

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APPENDIX I

LEGAL DEFINITIONS OF PETROLEUM PRODUCTS IN UNITED KINGDOM

Petroleum

"Includes any mineral oil or relative hydrocarbon and natural gas existing in its natural condition in strata, but does not include coal or bituminous shales or other stratified deposits from which oil can be extracted by destructive distillation".

(Petroleum (Production) Act, 1934, sect. 1.)

"Includes crude petroleum, oil made from petroleum, or from coal, shale, peat or other bituminous substances, and other products of petroleum".

(Petroleum (Consolidation) Act, 1928, sect. 23.)

"Crude petroleum or shale oil, any hydrocarbon product of crude petroleum or shale oil, excluding propane or butane, and any hydrocarbon oil made by the hydrogenation of:

"(*a*) crude petroleum or shale oil or any product derived from either of them; or

"(*b*) coal or any product derived from coal".

(The Control of Petroleum (Amendment) Order, 1948, article 2—S.I. 1948, No. 1420.)

Hydrocarbon Oils

"Petroleum oils, coal tar, and oils produced from coal, shale, peat or any other bituminous substance, and all liquid hydrocarbons". (Finance Act, 1928, sect. 2 (9).)

Light Oils

"Hydrocarbon oils of which not less than fifty per cent. by volume distils at a temperature not exceeding one hundred and eighty-five degrees centigrade, or of which not less than ninety-five per cent. by volume distils at a temperature not exceeding two hundred and forty degrees centigrade, or which give off an inflammable vapour at a temperature of less than 22·8 degrees centigrade when tested in manner prescribed by the Acts relating to Petroleum".

(Finance Act, 1928, sect. 2 (3).)

Petroleum Spirit

"Such petroleum as when tested in the manner set forth in Part II of the Second Schedule to this Act gives off an inflammable vapour at a temperature of less than seventy-three degrees Fahrenheit". (Petroleum (Consolidation) Act, 1928, sect. 23.)

"Petroleum spirit as defined in Section 23 of the Petroleum (Consolidation) Act, 1928, and any other inflammable liquid or mixture or substance which, when tested in the manner set forth in Part II of the Second Schedule to that Act, gives off an inflammable vapour at a temperature of less than seventy-three degrees Fahrenheit".

(The Factories (Testing of Aircraft Engines, Carburettors and other Accessories) Order, 1944—SR & O., 1944, No. 495.)

Motor Spirit

"Hydrocarbon oil, of which the volume distilling when tested by the method hereinafter specified, at a temperature not exceeding one hundred and eighty-five degrees centigrade, is not less than fifty per centum, or, at a temperature not exceeding two hundred and forty degrees centigrade, is not less than ninety-five per centum, or which when tested by the method hereinafter specified has a closed flash point less than seventy-three degrees Fahrenheit".

(The Control of Petroleum (Amendment) Order, 1948, article 2.—S.I.1948, No. 1420.)

Kerosene

"Hydrocarbon oil which when tested by the method hereinafter specified has a closed flash point not less than seventy-three, and not greater than one hundred and fifty, degrees Fahrenheit".

(The Control of Petroleum (Amendment) Order, 1948, article 2.—S.I. 1948, No. 1420.)

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"Hydrocarbon oils which are not light oils as defined in subsection (3) of section two of the Finance Act, 1928, and of which more than fifty per cent. by volume distils at a temperature not exceeding 240 degrees centigrade". (Finance Act, 1947, sect. 1 (4).)

Gas Oils

"Hydrocarbon oils of which not more than fifty per cent. by volume distils at a temperature not exceeding 240 degrees centigrade, and of which more than fifty per cent. by volume distils at a temperature not exceeding 340 degrees centigrade". (Finance Act, 1947, sect. 1 (4).)

Fuel Oils

"Hydrocarbon oils which contain in solution an amount of hard asphalt of not less than one half of one per cent". (Finance Act, 1947, sect. 1 (4).)

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4. *Lloyd's List and Shipping Gazette.* (Daily.)
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3. —— *Financial Statements.* (Annual.) H.M.S.O.
4. Customs and Excise: *Annual Reports of the Commissioners of H.M. Customs and Excise.* H.MS.O.
5. *The Economist: Records and Statistics Supplement.* (Weekly.)
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7. *London and Cambridge Economic Service Bulletins* (1922–1951). (Quarterly.)
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General

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British

1. *Institute of Petroleum Journal* (monthly),
2. *Petroleum* (monthly),
3. *Petroleum Press Service* (monthly),
4. *Petroleum Times* (fortnightly),
5. M. E. SKINNER: *Oil and Petroleum Yearbook.*

American

1. *National Petroleum News* (weekly),
2. *Oil and Gas Journal* (weekly),
3. *World Oil* (monthly),
4. *World Petroleum* (monthly),

and in the Annual Reports of the leading Petroleum Companies.

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REPORT OF THE COUNCIL

For the FINANCIAL YEAR *ended December 31st, 1951, and for the* SESSIONAL YEAR *ended June 26th, 1952, presented at the* ONE HUNDRED AND EIGHTEENTH ANNUAL GENERAL MEETING *of the* ROYAL STATISTICAL SOCIETY, *held at the London School of Hygiene and Tropical Medicine, W.C.1, on June 26th, 1952.*

Loyal Address

ON the occasion of the death of King George VI a loyal address of condolence was sent to Her Majesty Queen Elizabeth II in the following terms:—

TO THE QUEEN'S MOST EXCELLENT MAJESTY:

May it please Your Majesty,

We, the President and Council, representing the general body of Fellows of the ROYAL STATISTICAL SOCIETY humbly approach Your Majesty with an assurance of our loyal attachment to Your Majesty's Throne and Person and of our sincere and respectful condolence with Your Majesty and the Royal Family, and in particular with Her Most Gracious Majesty, the Queen Mother, on the sorrowful occasion of the death of our beloved Sovereign, His Majesty King George the Sixth. His late Majesty commanded the affection and admiration of all freedom loving peoples in the United Kingdom, in his Commonwealth and in other lands by his unfailing devotion to duty during a reign fraught with war and national problems of unparalleled difficulty. Throughout these anxious years he sought with single mindedness to promote and serve the best interests of his subjects. He shared with them their joys and their triumphs; he identified himself with them in their sorrows and distress.

The Fellows of the ROYAL STATISTICAL SOCIETY are proud that His late Majesty was throughout his reign their Patron.

We desire to assure Your Majesty of our respectful and dutiful homage on Your Accession to the Throne. So far as it may be within the power of this Society to assist Your Majesty's Ministers and Councillors in their deliberations, particularly on matters affecting the welfare of Your Majesty's subjects, we offer to Your Majesty, with our humble duty, the resources and experience of the Society's Fellows.

The Society has now been privileged to enjoy the royal patronage for over a century and we venture to express the hope that it may continue to merit and receive Your Majesty's own gracious patronage.

We pray that Your Majesty, supported by His Royal Highness the Duke of Edinburgh, may long enjoy a peaceful and illustrious reign over the people united in allegiance to the British Crown.

A gracious acknowledgment has been received.

Number of Fellows

At December 31st, 1951, the number of Fellows was 2,307, thus establishing another record in the history of the Society. The increase during the year of 114 was the result of 228 additions to, and 114 losses from, the roll. The additions were slightly larger than in the previous year (222), but still below those for each of the three immediately post-war years. In view of the exceptional circumstances responsible for the large numbers of additions in 1946 and 1947 comparison with the experience of those years is not valid, and the figure for 1951 compares most favourably with those of the later years. The losses of 114 exceed, it will be noted, those of any previous year but this is in part due to the fact that 15 life subscribers whose addresses have been unknown for at least five years have been removed from the roll. Since the absolute number of resignations must tend to increase with an increase in the number of Fellows, a rise in resignations could have been expected; but this has not in fact occurred.

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During the early months of 1952 the number of Fellows has further increased, and at the end of April was 2,343.

The number of Honorary Fellows at December 31st, 1951, was 14, including 7 Presidents for the time being of other Societies concerned with the advancement of statistical knowledge. Included in the 2,307 ordinary Fellows at the end of 1951 were 106 representing corporate bodies or institutions.

Calendar Year	*Number of Fellows (excluding Honorary Fellows)*		
	Lost by Death, Withdrawal or Default	*Elected, or Restored to the Roll*	*On the Roll at December 31st*
1940	76	47	1,079
1941	65	60	1,074
1942	69	74	1,079
1943	61	121	1,139
1944	29	159	1,269
1945	29	177	1,417
1946	56	287	1,648
1947	75	263	1,836
1948	96	238	1,978
1949	103	189	2,064
1950	93	222	2,193
1951	114	228	2,307

Losses by Death

The Council regrets the loss by death during the year ended April 30th, 1952, of the undermentioned Fellows:

	Date of Election
Ashpole, D. K.	1951
cp†*Chapman, Sir Sydney, K.C.B., C.B.E., M.A.	1903
Chaston, John, O.B.E., F.C.I.S.	1913
Dawson, T. R.	1942
Elsas, Moritz John	1934
Everett, Sir Percy W.	1896
Fazakerly, T. W., F.I.I.A., A.I.P.E., F.C.C.S.	1949
Gledhill, A. H., J.P., M.I.M.E., F.C.W.A.	1929
Henderson, Sir Hubert D.	1920
Hudson, H. W.	1918
*Khras, M. J. S., M.S.A.	1906
Long, F. A.	1950
Walmsley, C. C., F.C.I.S., F.I.A.C.	1946
*Yeatts, M. W. W., M.A., C.S.I., C.I.E.	1948
cp†*Yule, G. Udny, C.B.E., M.A., F.R.S.	1895

* Life Fellow. *c* Served on Council.
† Has received a Guy Medal. *p* Contributed to *Proceedings*.

With the death of Mr. Udny Yule the Society has lost an outstanding Fellow. His name was internationally a household word to generations of students whose introduction to statistics was by way of his text-book and whose further interest in the subject was stimulated by his many contributions to the Society's journal and elsewhere. He was first elected to the Council in 1898; in 1907 he was elected an Honorary Secretary and served in this capacity for 12 years. He was President of the Society for the two sessions 1924/5 and 1925/6, and with the award in 1911 of a Guy Medal in gold he received the Society's highest honour. His affection for the Society was evident not only from the active part he took in its affairs for over 40 years, but finally from the fact that in his will he left to it such books and journals as may be of interest to the Library and one-half of the residue of his estate (subject to two life interests).

Sir Sydney Chapman was elected nearly 50 years ago. He served on the Council between 1911 and 1920 and was a Vice-President for the two sessions 1916/17 and 1917/18. He was awarded a Guy Medal in silver in 1915. The several papers he contributed (jointly with others) were a reflection of the interests that engaged his attention in the Board of Trade, where he achieved high rank as Permanent Secretary and later as Economic Adviser to the Government.

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It was in the field of economics rather than that of statistics that Sir Hubert Henderson was so greatly distinguished. Nevertheless, he took an active part in the Society's meetings on more than one occasion, and as recently as December, 1950, was one of the main contributors to a discussion on the Reports of the Royal Commission on Population of which he had been the Chairman. The Council deeply regrets the loss of one whose public distinction was widely acknowledged, and whose relatively early death deprived him of the Wardenship of All Souls' College, Oxford, to which he had just been appointed.

Mr. Yeatts was for many years a member of the Indian Civil Service, particularly the Census Commission of India, and was responsible for the Census taken in 1950.

The Council also learned with regret of the death of Mr. J. I. Craig, who was a victim of the riots in Cairo in January, 1952. Mr. Craig was closely identified with the statistical service of Egypt and was well known in international statistical circles. He was a Fellow of the Society from 1924 to 1941 and a Member of the International Statistical Institute.

Vice-Presidents

For the Session 1951/52 the President appointed as Vice-Presidents of the Society Mr. H. Campion, Mr. R. F. George, Dr. J. O. Irwin and Mr. L. H. C. Tippett.

Meetings of the Society

The Society has continued to hold its Ordinary General Meetings in the lecture theatre at the London School of Hygiene and Tropical Medicine, and the Council takes this opportunity of expressing its gratitude for the facilities thus placed at the Society's disposal by the Board of Management and the Dean of the School.

The papers read during the Session have been as follows:

1951	
November 28th	HOUTHAKKER, H. S. Pre-War Family Budgets.
December 19th	BARNA, Dr. T. The Interdependence of the British Economy.
1952	
January 23rd	RUDD, E. Estimates of Expenditure on Road Transport and of Vehicle Mileage in Great Britain.
February 27th	PETERSON, A. W. Statistics of Gambling.
March 26th	SAUNDERS, C. T. Consumption of Raw Materials in the United Kingdom 1851–1950.
April 23rd	ADELSTEIN, A. M. Accident Proneness: A Criticism of the Concept based upon an Analysis of Shunters' Accidents.
May 28th	RYAN, J. Statistics of Tins and Cans.

Attendances have ranged between 59 and 116 with an average of 92.

The Cambridge Conference

A Conference of the Society was held at Cambridge, September 21st to 23rd, 1951. The Conference was opened by Dr. S. C. Roberts, Vice-Chancellor of Cambridge University. The following papers were read:—

(I) Papers read at meetings of the whole Conference:

MOSER, C. A., Quota Sampling.
BOOKER, H. S., and DAVID, S. T. Comparisons of Answers obtained by Experienced and Inexperienced Interviewers.
SEERS, D. The Distribution of the National Product.
PEARSON, E. S., and WISHART, J., opened a discussion on the Teaching of Statistics.

(II) A series of papers on general and applied topics:

BAILEY, N. T. J. The scope of Medical Statistics.
CANE, V. R. Learning Processes in a Simple Choice Situation.
COLE, D., and UTTING, J. E. G. The Economic Structure of Cambridgeshire.
ELLINGER, A. G. The Visual Approach to Investment.

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(III) A series of papers on methodology:

BRAITHWAITE, R. B. The Empirical Definition of Probability.
LINDLEY, D. V. Probability and Inference.
GOOD, I. J. Rational Decisions.
COX, D. R. Recent work on Systematic Experimental Designs.

(IV) Short contributed papers:

ANSCOMBE, F. J. Large-sample Theory of Sequential Estimation.
BOX, G. E. P. Multifactorial Designs of the First Order.
HARTLEY, H. O. Fitting Polynomials to Series with Missing Values.
HOUTHAKKER, H. S. The Application of an Electronic Computer to Statistical Work.
JOWETT, G. H. The Removal of Trends and Oscillatory Movements in Regression Analysis.
LAURENT, A. G. *A priori* Probability.
LESER, C. E. V. Men and Women in Industry.
MARTIN, L. The Significance of an Experimental Result.
WATSON, G. S. Serial Correlation in Regression Analysis.
WISHART, J. Moments of the *k*-statistics from Finite Population Samples.

Visits were arranged to various laboratories. About 240 persons in all attended the Conference. The Council's thanks are due to Mr. F. J. Anscombe, Mr. C. F. Carter, Dr. H. E. Daniels and Dr. J. Wishart, who were responsible for local arrangements.

The Research Section

Professor M. S. Bartlett was elected Chairman of the Research Section, and Mr. F. J. Anscombe has served for a second year as Honorary Secretary. Other members of the Section's Committee have been: Dr. P. Armitage, Dr. F. N. David, Mr. M. J. R. Healy, Mr. D. V. Lindley, Dr. P. A. Moran, Mr. D. Newman, Mr. R. L. Plackett, Dr. C. A. B. Smith, with Mr. E. C. Fieller and Professor M. G. Kendall nominated by the Council, and Dr. J. O. Irwin an *ex-officio* member as Editor of Series B of the *Journal*. Dr. Moran resigned from the Committee in December on being appointed to a Professorship in Australia, and Mr. K. D. Tocher was co-opted in his place.

The papers read during the Session have been as follows:—

1951	
October 31st	ARMITAGE, P. The Statistical Theory of Bacterial Populations Subject to Mutation.
1952	
January 16th	TOCHER, K. D. The Design and Analysis of Block Experiments.
March 19th	PLACKETT, R. L., and HEWLETT, P. S. Quantal Responses to Mixtures of Poisons.
May 21st	HEALY, M. J. R. Some Statistical Aspects of Anthropometry.

The Industrial Applications Section

The Section Committee, which co-ordinates the functions of the separately organized Local Groups and links them with the Society has consisted of Mr. D. J. Desmond, Dr. B. P. Dudding, Mr. Philip Lyle, Mr. A. W. Swan (appointed by the Council); Mr. G. H. Jowett, Miss J. Keen, Mr. E. D. van Rest (appointed by the 1950–51 Section Committee; and the Chairman and Secretaries of each of the Local Groups. Mr. van Rest was elected Chairman and Miss Keen, Honorary Secretary.

The Local Groups have continued to hold discussion meetings arranged by their Committees. The officers of these Committees were:

Group	*Chairman*	*Honorary Secretary*
Birmingham and District	Dr. D. G. Beech	Mr. C. H. Leigh-Dugmore
London	Mr. E. C. Fieller	Mr. P. J. Stanley
North-Eastern	Mr. N. J. Squirrell	Mr. H. Arnell
Sheffield	Mr. W. T. Hale	Mrs. J. Stewart
South Wales	Dr. T. V. Starkey	Mr. E. Lloyd
Tees-side Sub-Group	Mr. H. Kenney	Mr. J. T. Richardson
Mersey-side	—	Mr. R. L. Plackett

After five years the Tees-side Sub-Group of the North Eastern Group was formally disbanded by the Section Committee on December 14th, 1951. Despite every effort of the Local Committee

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and particularly of its Secretary, Mr. Richardson, attendance at meetings no longer warranted its continuance.

On January 31st, 1952, an inaugural meeting was held in Liverpool to form a Merseyside Group. About 120 people attended. The meeting was addressed by the Lord Mayor of Liverpool and by Mr. Philip Lyle, Dr. B. P. Dudding and Mr. O. P. Perrin of Messrs. Dunlop, who was organizing secretary. The chair was taken by Mr. Willacy Kuhn of Kresta Foundry and Engineering Co., Ltd. For a short period the Group will function informally.

On April 1st, 1952, a meeting was held in Leicester to consider the formation of a Leicester Group. The meeting, with an attendance of about 50, was addressed by Mr. Keith Boyd of British Timber and Miss Keen, Honorary Secretary of the Section. The Chair was taken by Mr. M. J. Moroney of the Leicester College of Technology and Commerce, who had organized the meeting. The resulting Group will function informally until its adoption by the Section Committee. Mr. Boyd was elected Chairman and Mr. D. Bramley Honorary Secretary. A full programme will begin next Session.

At the end of 1951 the membership of the Section was approximately 550, of whom about 340 were Fellows. During the Session 35 discussion meetings were held: 7 each in Birmingham, London, Newcastle and Sheffield, 2 in Crumlin (Mon.), 2 each in Liverpool and Newport, and 1 in Cardiff.

The subjects for discussion have been as follows:

Birmingham and District Group

1951	
September 26th	The Precision of Statistical Tests—D. G. Beech.
October 24th	Statistics in Trouble Shooting—E. A. G. Knowles.
November 28th	A Comparison of Different Methods of Inspection—B. H. P. Rivett.
1952	
January 2nd	The Statistical Approach to Time Study—D. J. Desmond.
January 30th	Problems of Quality Control in a Rubber Factory—M. G. Peakman.
February 27th	Short Cut Analysis of Variance based on Range—H. O. Hartley.
March 26th	Congestion Problems in Industry—J. Murdoch.

London Group

1951	
October 5th	An Experiment on the Accuracy of Time Studies—L. S. Vallance.
November 2nd	Making Practical Decisions on Statistical Data—Professor G. A. Barnard.
December 7th	The Planning of Experiments in the Chemical Industry—G. E. P. Box. (Joint Meeting with the Society of Chemical Industry, London Group.)
1952	
February 1st	The Study of Unbalanced Data from a Process including Several Recurring Changes—J. Keen and D. J. Page.
March 7th	Some Applications of Statistical Methods in Concrete Research—A. Battersby.
April 4th	Stochastic Problems of Storage Systems—H. Herne and D. G. Nickols.
May 2nd	The Extraction of Data from Old Records—W. A. Pridmore.

Merseyside Group

1952	
February 25th	A Control Chart for the Percentage of a Chemical Ingredient—E. F. Livesey.
March 11th	Answers to Members' Statistical Problems—B. P. Dudding.
May 2nd	Statistically Designed Experiments in the Chemical Industry—G. E. P. Box.

North Eastern Group

1951	
October 17th	Training Personnel in Quality Control—W. J. Ross.
November 21st	The Significance of Accident Records—H. Campell.
December 4th	Measurement of Productivity—D. J. Desmond. (Joint Meeting with the Association of Cost and Works Accountants.)
1952	
January 16th	The Rational Design of Experiments—G. E. P. Box. (Joint Meeting with the Society of Chemical Industry.)
February 20th	Statistics and Management—D. Gold.
March 19th	The Arithmetic of Statistics—D. Gold.
April 16th	Significance Tests in Action—J. M. Runcie.

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Sheffield Group

1951	
September 27th	Side Lights on the Error Curve—J. F. Hinsley.
October 25th	A Comparison of Different Methods of Inspection—B. H. P. Rivett.
November 29th	Elementary Statistical Methods as an Aid to Foundry Production Control—W. G. A. Jenkins.
1952	
January 31st	Some Applications of Sequential Sampling to Steel Works Problems—G. F. Komlosy.
February 28th	The Use of Experimental Designs in University Technological Research—N. L. Franklin.
March 27th	Computational Short Cuts and Calculating Machines—H. O. Hartley.
April 24th	The Accuracy of the Sampling of Coal—J. Hebden and G. H. Jowett.

South Wales Group

1951	
November 23rd	Statistics in Trouble Shooting—E. A. G. Knowles.
December 14th	Quality of Information—L. T. Wilkins.
1952	
January 25th	Statistical Aids to Management—L. H. C. Tippett.
February 22nd	The Precision of Statistical Tests—D. G. Beech.
April 25th	A Discussion on Sequential Analysis—J. Parry Lewis.

Study Section

Mr. E. Shankleman has been Chairman of the Study Section during the current session, with Miss S. V. Cunliffe as Honorary Secretary. Miss Iris Douglas and Mr. L. T. Wilkins have represented the Council. The other members of the Committee were: Mr. W. R. Foster (representing the Bristol Group), Mr. C. A. Moser, Dr. C. Nuttall, Mr. M. Rudd, Mr. G. P. Salter.

Three Committee meetings have been held, and the following general meetings were held in London:

1951	
October 10th	Some Statistics of a London University Teaching Hospital covering the last Sixty Years—F. D. Bushell.
November 14th	Market Research—the Relationship between Client and Practitioner—A. Anson and T. Cauter.
December 19th	Pitfalls of Financial Statistics—N. Crump.
1952	
January 9th	Population Projections: an Assessment of their Value generally and some Notes on Technical Problems—P. R. Cox.
February 13th	Road Accident Statistics—Dr. F. Garwood.
March 12th	The Value of the Census of Distribution—D. A. Clark.
April 9th	The problem of Estimating Housing Needs—Dr. M. J. Elsas.
May 14th	The Measurement of the Understanding of Radio Talks—J. Trenaman.
June 11th	Annual General Meeting, followed by a Discussion on the Prediction of Movements in Economic Indices.

These meetings have in general been well attended, with between 40 and 50 people present at most of them.

The Group in Bristol has also held monthly meetings, and the following subjects have been discussed:

October 16th	Some Problems in the Use of Consumer Panels—R. N. Wadsworth.
November 20th	Factorial Design—B. K. Kelly.
December 18th	The Television Viewing Public—R. J. E. Silvey.
January 15th	The Logic of Probability Statements—S. Körner.
February 13th	National Food Survey—W. L. Kendall.
March 18th	The Statistical Approach—G. F. Todd.

Mr. W. R. Foster was appointed Chairman of the Group for the session, and Mr. H. C. Mackenzie, Honorary Secretary. An attendance of 20 to 30 at most meetings has more than justified the opening of the Bristol Group.

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In addition, during the autumn of 1951, the Study Section set up a Study Circle to consider Medical Statistics. This Circle has met on six occasions, in the Westminster Hospital Medical School.

The Council is indebted to The Electric Light Manufacturers' Association, Bristol University, and the Westminster Hospital Medical School, who have kindly supplied the Section with meeting-places.

Guy Medal

The Council, unanimously accepting the recommendation of its Executive Committee, had pleasure in awarding a Guy Medal in silver to Professor M. S. Bartlett, D.Sc. Professor Bartlett's distinction as a teacher and research worker in mathematical statistics is known to all, and Fellows will not need to be reminded of his contributions to the Journal during the past several years. The Council in making this award took particular note of his contribution, "Some Evolutionary Stochastic Processes," to the Symposium on Stochastic Processes, read to the Research Section of the Society on June 9th, 1949. Professor Bartlett is one of those now actively concerned in making arrangements for the forthcoming week-end conference to be held in Manchester jointly with the Manchester Statistical Society. The Council is especially happy to honour one whose activities strengthen the friendship that has linked the two Societies for over a hundred years.

International Statistical Institute

At the meeting of the International Statistical Institute in Delhi in December, 1951, there attended from this country 9 Fellows of the Society. The Council offers its congratulations to Dr. F. N. David and Dr. D. J. Finney on their election to membership of the Institute.

The Society's Examinations

Thirty candidates for all or part of the Society's Certificate and two for its Diploma presented themselves for the examinations held on March 26th, 27th and 28th, 1952. Certificates were awarded to the following Fellows—

Bonner, Basil Bradlaugh.
Davies, Raymond Arthur.
Graham, Conrad.
Kenward, Evelyn Maude.
Naylor, Geoffrey Charles.
Martin, Michael Egerton.
Williams, John Lawrence.

This year, for the first time, provision was made for the Certificate examination to be held overseas, and the Council is grateful to Mr. J. R. H. Shaul (Salisbury, Southern Rhodesia) and Mr. D. R. Westgarth (Kuala Lumpur), who were responsible for the conduct of the examinations in these centres.

The Council has once again to acknowledge its indebtedness to the London School of Hygiene and Tropical Medicine for granting the necessary facilities for holding the examinations in its Department of Medical Statistics and Epidemiology and to those Fellows of the Society who acted as invigilators. It also extends its thanks to the Examinations Committee and others who have helped the Committee in its work. The membership of the Committee has been: Mr. E. C. Fieller (Chairman), Dr. N. L. Johnson (Honorary Secretary), Professor R. G. D. Allen, Professor G. A. Barnard, Mr. B. Benjamin, Dr. D. J. Finney, Dr. H. O. Hartley and Professor E. S. Pearson.

The Society's Journals

The ambition of the Editors to achieve the publication of the four parts of Series A for 1951 within that calendar year only just failed to be realized. Whereas Part IV, 1950, was issued in February, 1951, the corresponding number of 1951 appeared in January, 1952. There was thus some slight improvement in the punctuality of publication but the ambition remains, and the Editors continue to hope that the four parts will appear within the limits of the calendar year. During 1951 there were issued four parts of Series A and two of Series B. The Editorial panel responsible for Series B has consisted of:

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Dr. J. O. Irwin (Chief Editor).
Mr. F. J. Anscombe.
Professor G. A. Barnard.
Professor M. S. Bartlett.
Dr. H. E. Daniels.
Dr. O. L. Davies.
Mr. E. C. Fieller.
Dr. H. O. Hartley.
Mr. D. G. Kendall.
Professor M. G. Kendall.
Dr. C. A. B. Smith.
Mr. J. R. N. Stone.
Dr. F. Yates.

During Dr. Irwin's visit to India and Malaya Mr. D. G. Kendall acted as Chief Editor of Series B.

The special series of articles published under the general guidance of Professor Kendall has continued to appear in Series A. The Council approved the issue of 20 of the series in book form and the necessary arrangements were made with Messrs. Oliver and Boyd. The Council extends to Professor Kendall its appreciation of his continuing work in this venture.

Fellows will recall that the Council expressed in its last Annual Report some concern over the increasing size and cost of the Journal. In spite of continued attention by the Editors, the Journal unfortunately shows little evidence of contracting in size, while for reasons outside their control the costs of publication continue to rise. It is clear that the essential economy in this major item of the Society's expenditure can be achieved only by a much more rigorous control on the contents than has yet been imposed. There has been a tendency in recent Sessions for the papers submitted for reading at ordinary meetings to assume increasing length. The Council earnestly hopes that any such tendency will not be assumed to establish a criterion of what is expected of papers offered for reading. It may be that authors who would otherwise feel inclined to submit papers may be discouraged by their inability to produce a contribution of the length attained by several that have recently been accepted. There need be no apprehension on this score, and the Council would welcome shorter papers which can well make up in quality and conciseness what they lack in quantity. Indeed the Council feels that unless papers offered to the Society are materially reduced in size it may become necessary to impose a limit on them.

Fellows are already aware that the first number of the new Journal foreshadowed in the last Annual Report has now appeared under the title *Applied Statistics*. The Council has pleasure in recording its appreciation of the work of the Committee responsible for bringing this new Journal into being. In particular, the Council's gratitude is cordially extended to Mr. L. H. C. Tippett for his editorial services. The members of the Editorial Committee have been: Mr. L. H. C. Tippett (Chairman and Editor), Dr. O. L. Davies, Mr. R. F. Fowler, Dr. J. O. Irwin, Mr. G. H. Jowett, Mr. Philip Lyle, Mr. C. A. Moser, Mr. E. D. van Rest, Mr. E. Shankleman, Mr. L. T. Wilkins. With only one number published it is far too early to report on the financial results of *Applied Statistics*. The Council is, of course, prepared, if necessary, to sustain a modest loss for the first year or so, since it is unlikely that a new technical publication, however attractively presented, can be relied on to cover its expenses from the beginning. The Council would, however, urge all Fellows of the Society to bring the Journal to the attention of potential subscribers.

The Library

The Library Committee of the Council report that the services given to Fellows and others authorized from time to time to use the Library during 1951 can be summarized statistically as follows:

	1949	*1950*	*1951*
Number of Fellows who borrowed books	345	370	347
Number of effective applications for books	1,169	1,371	1,180
Number of volumes borrowed by Fellows	2,032	2,580	2,112
Number of signatures of Fellows and visitors using the Reading Room	586	597	556
Non-serial works added to the Library	537	492	529

About 400 weekly, monthly and quarterly periodicals were received during 1951.

The Library Committee has continued to study all requests made for books which could not be met from the Library's resources. The number of works or titles applied for and not in the Library declined further from 281 in 1950 to 190 in 1951.

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The grant of $20,000 from the Rockefeller Foundation, to which reference was made in last year's Report of the Council, has made it possible to take the first steps in strengthening and improving the services provided by the Library. Following a special review of the Library made by the Deputy Librarian of the University of London at the Council's request, an Assistant Librarian was appointed in July, 1951, to deal with indexing and cataloguing. Considerable progress has already been made on producing an accurate record of the Library's substantial holdings of periodicals.

The late Mr. Udny Yule gave many valuable books and papers to the Library during his lifetime. His first donation was in 1907, and in 1931 he made a gift of over 300 volumes. As part of his generous bequest to the Society the Library has received under the terms of his will a further valuable collection of some 474 works and many periodicals. By far the larger part of what is now a fine collection of early books on the theory of statistics in the Library came to the Society through Mr. Yule's generosity.

The Society has also to record its thanks to the Institute of Actuaries for a donation of some 40 interesting old works on probability and other subjects of much interest to the Society.

Housing

The Council during the past year has been aware of the increasing urgency of the need of finding premises to afford the Society a temporary home. The background of the problem is that the lease of 4, Portugal Street, expires in some five years. The likelihood of the Society securing its promised accommodation in the Central Science Building under the auspices of the Royal Society within that period is beyond the most optimistic expectation. If nothing is done in the early future the Society therefore faces the prospect of losing its existing accommodation in 5 years' time with, as far as can be seen, no greater likelihood of acquiring a suitable alternative then than appears at present. Many notices of premises, for sale or to be rented, have been received, but for reasons of price or space they have had to be rejected. One opportunity, however, has been very closely considered, and gives more promise of meeting the Society's requirements than any other yet considered. The premises are situated just north of Oxford Street in a professional neighbourhood and are available on a lease of 28 years. The total area is very slightly larger than that at Portugal Street but much less than is necessary to meet the Society's complete requirements. It is, however, abundantly clear that to secure the entire space required would involve an expense far beyond the present resources of the Society. Although, as stated above, the premises under consideration are rather larger than those occupied at present, the available area is broken up into a much larger number of rooms distributed over five floors. This unfortunately means that it may not be possible to accommodate the whole of the Library there. The Council feels that this must be accepted and is endeavouring to find additional space where the less frequently consulted contents of the Library can temporarily but accessibly be stored. On the other hand, the premises in question should enable the office staff to work in more adequate and congenial surroundings than at present. In this connection the Council wishes to express its deep appreciation of the loyal and arduous service invariably given by the Secretary and the Librarian, and their staff. The circumstances in which they have worked for many years are far from ideal, and it is hoped that such accommodation as the Society may acquire will afford materially improved conditions.

At the time of writing this Annual Report the Society's Architect is preparing estimates for certain essential alterations in the proposed new premises. These will inevitably involve considerable expense, but bearing in mind the limited assets of the Society, only the minimum alterations necessary are being considered. Meanwhile, the Society's Solicitors are preparing a draft contract and safeguarding other cognate considerations such as planning permission and the position of the Society in respect of exemption from rates. The premises concerned are more likely to serve the Society's purposes than any others that have come to the Council's notice, but many considerations have yet to be examined and it is not possible (at the time of writing) to report a final decision.

Finance

Abstracts of the Honorary Treasurer's Accounts, viz., the Statement of Income and Expenditure for the year 1951 and the Balance-Sheet as at December 31st, 1951, together with the Auditor's report thereon, are contained in Appendices B and C.

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Income, excluding Life Composition Fees received during the year and the interest earned on the Benefaction of £30,000, increased from £10,279 in 1950 to £11,596 in 1951. Fellowship subscriptions were higher by £454 but sales of the *Journals* were lower by £202—the result of publishing only 4 issues of *Journal A* in 1951 compared with 5 issues in 1950. Sales from *Journal B* rose by £173. A first instalment, amounting to £1,735, of the Rockefeller Grant was received during the year, and £666, equal to the amount spent under approved headings, has been included in the income for the year. The balance of £1,069 is shown in the Balance-Sheet.

Expenditure, which rose from £8,585 in 1949 to £10,786 in 1950, increased further to £11,673 in 1951. There were increases of £344 in salaries and wages, £142 on stationery and miscellaneous printing, and £76 on the Library. Publication and Distribution Expenses of the *Journals* declined from £6,280 to £5,928. This was due partly to the fact that 4 issues of *Journal A* were published in 1951 compared with 5 issues in 1950, and partly to a reduction of £430 in the cost of *Journal B*. Expenditure on publication and distribution of *Journal A* exceeded receipts from sales by £749 in 1951 (4 issues) compared with £1,306 in 1950 (5 issues). For *Journal B* the excess of expenditure was reduced from £1,172 to £579. The publication of the Sheffield Conference Papers cost £393.

The Council decided that the Life Composition Fees of compounders who die during the year should, as from 1951, be transferred to the Statement of Income and Expenditure instead of to the Accumulated Fund. Accordingly a sum of £457 representing the Composition Fees of compounders who died in 1951 (£142) or were presumed to have died in earlier years (£315) has been included in Income.

As a result of the year's operations there was a deficit of £77 compared with a deficit of £507 in 1950.

Composition Fees received during the year fell from £418 in 1950 to £241 in 1951. After allowing for the composition fees of compounders who died during the year or were presumed to have died in previous years, the Composition Fee Fund, maintained at the total of composition fees received from Fellows still living, amounted to £7,007 at the end of the year.

In December the Benefaction of £30,000, which had been invested in 2¼ per cent. Exchequer Stock 1955, was transferred to 2½ per cent. Funding Loan 1956/61. The interest earned during the year has not been included in income, but added to the Benefaction which now stands at £30,970 and is shown separately in the Balance-Sheet.

The Council and Officers

Professor Bradford Hill having now completed two years as President must retire from the chair. For ten years as an Honorary Secretary and two years as President, Professor Bradford Hill has served the Society in high office continuously for twelve years, and the Council is conscious of a deep sense of indebtedness to him for his unremitting services. Those whose privilege it has been to work closely with him are aware of his unceasing care for the Society, and the Council looks forward to the continued benefit of his wisdom and experience as he joins their ranks as a past President.

It was with much pleasure that the Council received the consent of Professor R. A. Fisher, F.R.S., to allow his nomination as President for the forthcoming Session. His eminence in the field of statistics is international and the Society is honoured by his acceptance of this office.

The Council greatly regrets that Mr. J. R. N. Stone has found it necessary to tender his resignation as Honorary Secretary in view both of pressure of work and of responsibilities necessitating his absence abroad. The Council is grateful to him for the services he has rendered, and is glad that he is able to continue to serve the Society as an ordinary member of the Council. In his place the Council invited Miss Iris Douglas to allow herself to be nominated for election as an Honorary Secretary. It records her acceptance with much satisfaction.

The retiring members from last Session's Council are Professor E. S. Pearson, Mr. H. Campion, Dr. B. P. Dudding, Mr. B. Benjamin, Professor R. A. Fisher and Mr. D. G. Kendall. The Council thanks these past members for their services.

In accordance with the Bye-laws, Fellows were invited to suggest the names of candidates for election to the vacancies on the Council for the forthcoming Session. These suggestions were duly considered, together with others made by the Council, and Mr. F. J. Anscombe, Professor G. A. Barnard, Professor D. G. Champernowne, Mr. R. Glenday, Mr. D. Newman and Mr.

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E. D. van Rest were recommended by the Council to fill the six vacancies for ordinary members of the Council. As no alternative proposals were received the Fellows named below will be announced at the Annual General Meeting on June 26th, 1952, as having been elected President, other officers and other members of Council for the Session 1952/53.

President

Professor R. A. Fisher, F.R.S.

Council

R. G. D. Allen.
†F. J. Anscombe.
†G. A. Barnard.
M. S. Bartlett.
W. R. Buckland.
*D. G. Champernowne.
E. Devons.
E. C. Fieller.
D. J. Finney.
*R. Glenday.
H. O. Hartley.
J. O. Irwin.
M. G. Kendall.
G. H. Jowett.
Sir George Maddex.
F. A. A. Menzler.
†D. Newman.
†E. D. van Rest.
J. H. Richardson.
J. Ryan.
L. G. K. Starke.
J. R. N. Stone.
A. W. Swan.
L. H. C. Tippett.
L. T. Wilkins.
J. Wishart.

Honorary Treasurer

R. F. Fowler.

Honorary Secretaries

R. F. George. Philip Lyle. Iris Douglas.

Honorary Foreign Secretary

R. F. George.

On behalf of the Council,

A. Bradford Hill,
President.

R. F. George
Richard Stone
Philip Lyle
} *Honorary Secretaries.*

June 1st, 1952.

Those marked * were not Members of Council during the preceding session; those marked † have never served on the Council.

APPENDIX A

From June, 1951 to May, 1952, inclusive, the candidates named below were elected Fellows of the Society:

Abrahams, Mrs. Dorothy.
Adelstein, Abraham.
Adkins, Brian.
Amaral, Maria Luiza de Azevedo.
Anastassiades, Paul L.
Andrew, John Everett.
Ashpole, Donald Kenneth.
Austin, John Hunt.

Baird, Cecil Gardner.
Ball, Joseph.
Barker, Rennie.
Beal, Colin.
Bedford, Edward Lewis.
Beer, Anthony Stafford.
Beer, Stephen Kenneth.
Benz, Norman.
Bennett, William Alfred.
Berent, Paul H.
Beresford, John Charles.
Berrisford, Harold Geoffrey.
Bizley, Michael Terence Lewis.
Bose, Raj Chandra.
Bostock, Charles Henry Gerald.
Boyd, Keith Tudor.
Blyth, Cecil Douglas.
Brace, Derrick Alan.
Brooks, Wilfrid Harold.
Brown, Valerie Edith.
Buckley, Thomas William Hurst.
Bunting, Alfred.
Byford, Gordon Holt.

Carden, Eric Stanley.

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Champness, John Howard.
Chandler, Kenneth Norman.
Chatterjie, Arun Kumar.
Chua, Seng Chew.
Churchill, John Desmond Chilcott.
Cohen Lionel.
Coombs, Kenneth Harold.
Curran, Christine.

Daltry, Cyril Tetlow.
David, Frederick John.
Davies, Glyn James.
Dawson, Raymond Francis Frederick.
Dettering, Thomas Peter.
Donaldson, William Anderson.
Duarte, Rolando.
Duckworth, Walter Eric.
Duncan, Ethel Helen Laing.

Edwards, Bernard.
Edwards, David Brenig.
Edwards, William Craig.
Ehrenberg, Andrew Samuel Christopher.
El-Adly, Mahmoud.
Eldin, S. S. Nour.
Ellis, Robert Frederick.
Emmett, Brian Patrick.
England, Leonard Rolfe.

Fitch, Elaine Rosemary.
Follett-Smith, Robert Redvers.
Forwell, George Dick.
Foster, John Myles.
Foster, William Richardson.

Gales, Bernard Henry.
Gardner, Walter Frank.
Gatenby, Norman Reginald.
Gellard, Melville Denis Joseph.
Ghose, Tariniprosad.
Gibson, John Walter.
Goh, Keng Swee.
Gore, Arthur Thomas.
Gorman, William Moore.
Graham, Conrad.
Greenlands, Reginald Harry.
Greenway, Harold Franklin.
Grundy, Peter Gwynne.
Gundry, Rona Geneva.

Haigh, John Randal.
Hampton, John Donald.
Hansman, Denis Alfred.
Hargreaves, John Allan.
Harrower, John.
Harwood, Charles Lloyd.
Hendry, Ian Frederic.
Holder, George Hayward.
Honoré, Louis.
Hopkins, John William.
Huitson, Alan.
Humphreys, William Robert.

Imison, Dorothy Hunter.
Isaac, Stanley Frank.

Jain, Danendra Dev.
James, Gilbert Oliver.
James, Stanley Francis.
Jenkins, William George Arthur.
Jones, Maurice William.
Jones, Robert Morley.
Jones, Walter George.
Jordan, Patricia.
Joseph, Montague Edward.
Joshi, Vinayak Mahadeo.

Kemp, Cecil David.
Keyfitz, Nathan.
Khan, Mohammed Yahya.
Kingston, Jorge.
Kirk, Andrew.
Knapp, Edward Ronald.

Lane, John.
Lane, Kenneth Frederick.
Langston, John George.
Laurent, André Gilbert Louis.
Leaf, Gerald Arthur Verno
Lee, Geoffrey.
Lee, Harry Gordon
Lee, Hee Seng.
Lever, Ernest Harry.
Lewis, William Arthur.
Linder, Arthur.
Logan, Andrew.
Love, John Walter Charles.
Lynch, Peter Donald.

McPhee, Angus.
Mallett, Sheila Yvonne.
Manley, Thomas Rae.
Manley, Yvonne.
Mannaberg, Kurt.
Marshall, John Thornton.
Martin, Michael Egerton.
Martin, Léopold.
Marvin, Ronald Arthur.
Mason, Walter Edwin.
Maunder, Wynne Frederick.
Mayne, Alan James.
Memoria, José Maria Pompeu.
Middleton, Bernard Francis.
Moore, Peter Gerald.
Moorthy, P. Krishna.
Morris, Graham John.
Murden, Kenneth Glover.
Murray, Geoffrey Lawrence.

Neil, John Denniss.
Nissim, Joseph Abraham.
Norris, Vera.
Nowik, Henry.

Page, Denys John.
Page, Ewan Stafford.
Pain, Basil Philip.
Pankhurst, Walter Demetrius.
Panthaki, Keki Rustom.
Parker, Wilfred John.
Parkinson, John Harry.
Parten, Henry Charles.
Paten, Robert Charles.
Peregrine, Gwilym Herbert.
Phillips, Hubert.
Pilley, Bruce Ian.
Potter, Joseph Bateman.
Prest, Alan Richmond.
Prevett, Ronald Lewis.

Quist-Arcton, Edward Akufo.

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Rätel, Philip Edward.
Rawlings, David Hugh.
Reeve, William John.
Robbins, John Everett.
Robbins, Richard Michael.
Rosenberg, Louis.

Saito, Kinichiro.
Sandham, William Kenneth.
Saunders, Eric.
Scouller, Colin Ernest Kerr.
Singh, Gurdev.
Smith, Alastair Bateson Lindsay.
Smith, John Kember.
Smith, Peter Harold.
Spencer, Ulric Max.
Stern, Babette Esther.
Stone, Peter A.
Styles, Harold Edwin.
Svenson, Joyce Doreen.
Swain, Joseph Frank.
Swanson, Grace Margaret.
Szlichter, Jan.

Tan, Hiang-Yong.
Taylor, William Brooking.
Thaiarry, Pricha.
Thawani, Vensi Detaram.
Thomas, Geoffrey Howell.
Thorne, Edwin Arthur.
Timmons, John Mervyn.
Titchmarsh, Henry Edward.
Trickett, William Henry.

Usherwood, Kenneth Ascough.

Vashi, Dinker Ghelabhai.
Vidakovic, Mirjana Cherry.

Waddams, Frank Christopher.
Wang, Ke-Ching.
Warrington, George Donald.
Waterman, Sheila Patricia.
Watson, Leslie Thomas.
Westbrook, Frank Herbert.
Westmacott, Michael Horatio.
Wheatley, Margaret Rosamund.
Wigmore, Margaret Elizabeth.
Wilford, Arthur Thomas.
Williams, Noel.
Wilson, Sir Reginald.
Woodroof, Eric Arthur.
Woolf, Barnet.

Yap, Fui-Chung.

Zia-I-Ghaus, S. M.

Corporate Representatives

Banfield, Francis Harrold,	*representing*	British Food Manufacturing Industries Research Association.
English, Horace William James,	*representing*	The Chartered Bank of India, Australia and China.
Freeborn, Kenneth Lionel Claude,	*representing*	The British Boot, Shoe and Allied Trades Research Association.
Galliner, Peter,	*representing*	The Financial Times Library.
Goodchild, Anthony Grayson,	*representing*	Dr. V. E. Yarsley (Research Laboratories) Ltd.
Jebson, Leslie Robert Henry,	*representing*	British Celanese Ltd.
Jenkins, Alun Evans,	*representing*	The Mond Nickel Co. Ltd.
Kadlec, Miroslav,	*representing*	The Office of the Czechoslovak Commercial Attaché.
Lee, Sidney John,	*representing*	The National Farmers' Union.
Paine, George,	*representing*	Statistics and Intelligence Division, Board of Inland Revenue.
Pendred, Victor W. J.,	*representing*	The Polytechnic School of Commerce, Regent Street.
Tuke, Anthony William,	*representing*	Barclays Bank Ltd.
Wake, William Charles,	*representing*	The Research Association of British Rubber Manufacturers.

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APPEN

STATEMENT OF INCOME AND EXPENDITURE

EXPENDITURE

1950 £	1950 £		1951 £	1951 £
	380	Rent		380
	332	House expenses		375
	1,952	Salaries and wages (including contribution to staff superannuation scheme)		2,296
	222	Pension		250
	21	Insurance		23
	4	Office and Library equipment		171
	103	Postage and telephone		168
	551	Stationery and miscellaneous printing		693
		Publication and distribution expenses:		
4,070		Journal, Series A (General) and reprints	4,138	
2,210		Journal, Series B (Methodological) and reprints	1,790	
	6,280			5,928
	—	Publication of Sheffield Conference Papers		393
		Library:		
155		Books	176	
121		Binding	176	
	276			352
	161	General Meetings—ordinary and annual		132
	22	Council and committee travelling expenses		41
		Expenses of sections:		
62		Research	58	
235		Industrial applications	207	
29		Study	27	
	326			292
	7	Guy Medal		7
		Examination expenses:		
36		Printing, stationery, postage etc.	40	
31		Examiners' fees	57	
	67			97
	37	Auditor's fee (1950)		37
	45	Miscellaneous expenses		38
	10,786			11,673
	418	Amount carried to Life Composition Fee Fund		241
	£11,204			£11,914

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DIX B

FOR THE YEAR ENDED 31ST DECEMBER, 1951

INCOME

1950 £	1950 £		1951 £	1951 £
		Annual subscriptions:		
5,149		Fellowship	5,603	
3		Research Section	2	
88		Industrial Applications Section	80	
3		Study Section...	13	
—	*5,243*		—	5,698
	50	Contribution from Royal Economic Society		50
	641	Dividends and interest (gross)		621
		Sales of Journal:		
2,764		Journal, Series A (General) and reprints	2,389	
1,038		Journal, Series B (Methodological) and reprints	1,211	
—	*3,802*		—	3,600
	3	Sales of other publications		3
		Examination receipts:		
104		Fees	136	
13		Sale of papers	15	
—	*117*		—	151
	400	Grant from Royal Society		350
	—	Grant from Rockefeller Foundation—expenditure appropriated thereto		666
	23	*Miscellaneous receipts*		—
	—	Transfer from Life Composition Fee Fund, being fees of compounders known to have died during year and of those presumed to have died in previous years		457
	10,279			11,596
	507	Deficit carried to Accumulated Fund		77
	10,786			11,673
	418	Life Composition Fees received during year		241
	£*11,204*			£11,914

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APPEN

BALANCE SHEET AT

FUNDS AND LIABILITIES

1950 £	1950 £		1951 £	1951 £
		Accumulated Fund:		
7,642		Balance at 31st December, 1950	7,212	
77		*Add: Amount transferred from Life Composition Fee Fund* ...	—	
7,719			7,212	
507		*Less:* Balance per Statement of Income and Expenditure ...	77	
	7,212			7,135
		Life Composition Fee Fund:		
6,882		Balance at 31st December, 1950	7,223	
418		*Add:* Life Composition Fees received during year	241	
7,300			7,464	
		Less: Transfers of fees of compounders known to have died during year, and for 1951 of those presumed to have died in previous years—		
77		*To Accumulated Fund*	—	
—		To Statement of Income and Expenditure	457	
	7,223			7,007
		Building Fund (per contra):		
1,283		Balance at 31st December, 1950	1,331	
48		*Add:* Income for year	49	
	1,331			1,380
		1950 Benefaction Fund (pre contra):		
—		Balance at 31st December, 1950	30,484	
30,000		*Amount of Benefaction*	—	
484		*Add:* Income for year	693	
30,484			31,177	
—		*Less:* Loss on realization of investment	207	
	30,484			30,970
		Liabilities and Income held in suspense:		
2,060		Sundry Creditors	2,754	
		Amounts received in advance:		
290		Annual subscriptions	262	
923		Payments for Journals	1,264	
46		Examination fees	35	
	3,319			4,315
—		Grant from Rockefeller Foundation	1,735	
—		*Less:* Expenditure during year appropriated thereto	666	
				1,069
	49,569			51,876
		Frances Wood Memorial Fund (per contra):		
503		Balance at 31st December, 1950	523	
20		*Add:* Income for year	21	
	523			544
	£50,092			£52,420

REPORT OF

I have obtained all the information and explanations which to the best of my knowledge and have been kept by the Society so far as appears from my examination of those books.

I have examined the above balance sheet and annexed statement of income and expenditure tion and according to the explanations given me the Balance Sheet gives a true and fair view of the gives a true and fair view of the income and expenditure for the year ended on that date.

5, London Wall Buildings, E.C.2.
13*th May*, 1952.

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DIX C

31ST DECEMBER, 1951

ASSETS

1950 £	£		1951 £	£
5,580		*Investments* at cost or under: £10,527 12*s.* 3*d.* 2½% Consols (Guy Bequest)	5,580	
1,185		£2,236 11*s.* 3*d.* 2½% Consols	1,185	
1,324		£1,864 14*s.* 1*d.* 3½% Conversion Loan	1,324	
490		£500 3½% War Loan	490	
1,486		£1,486 13*s.* 10*d.* 3% Savings Bonds 1955–65	1,486	
2,992		£2,970 1*s.* 10*d.* 3% Savings Bonds 1965–75	2,992	
2,000		£2,000 3% Defence Bonds	2,000	
100		£194 16*s.* 1*d.* 3% British Transport Guaranteed Stock 1978–88	100	
15,157				15,157
		(Market Value, *less* interest accrued, 31/12/50 £17,800, 31/12/51 £15,712.)		
1,331		*Building Fund*: £1,456 1*s.* 9*d.* 3½% Conversion Loan		1,380
		(Market Value 31/12/50 £1,349, 31/12/51 £1,194.)		
		1950 Benefaction Fund:		
—		£33,388 13*s.* 9*d.* 2½% Funding Loan, 1956/61	30,784	
30,157		*£30,000 2¼% Exchequer Stock, 1955*	—	
		(Market Value, *less* interest accrued, 31/12/50 £30,487, 31/12/51 £30,792.)		
253		Interest accrued	176	
74		Cash at Bank	10	
30,484				30,970
		Current Assets:		
510		Debtors and amounts paid in advance	205	
84		Arrears of subscriptions recoverable (estimated)	100	
172		Interest accrued on investments (gross)	172	
1,831		Cash at banks and in hand	3,892	
2,597				4,369
49,569				51,876
		Frances Wood Memorial Fund:		
300		£512 12*s.* 6*d* 3% British Transport Guaranteed Stock 1978–88	300	
		(Market Value, 31/12/50 £469, 31/12/51 £397.)		
223		Post Office Savings Bank Deposit	244	
523				544

NOTE.—No value is placed in the Accounts on—

(1) Journals and other publications in stock.
(2) Books in library.
(3) Pictures, furniture and equipment.

A. BRADFORD HILL, *President.*

R. F. FOWLER, *Honorary Treasurer.*

£50,092	£52,420

THE AUDITOR

belief were necessary for the purposes of my audit. In my opinion proper books of account which are in agreement with the books of account. In my opinion and to the best of my informa- state of the Society's affairs as at 31st December, 1951, and the statement of income and expenditure

A. RAE SMITH, Auditor.
Chartered Accountant.

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PROCEEDINGS OF THE ONE HUNDRED AND EIGHTEENTH ANNUAL GENERAL MEETING OF THE ROYAL STATISTICAL SOCIETY, held at the London School of Hygiene and Tropical Medicine, on Thursday, June 26th, 1952.

The Chair was taken by the President, Professor A. Bradford Hill, C.B.E., D.Sc., Ph.D.

The President presented the Report of the Council for the financial year 1951 and the session 1951–1952, and moved that it be received.

The President announced that it was with great pleasure he was able to inform the meeting that a letter dated June 23rd had been received from the Keeper of the Privy Purse stating that Her Majesty had been graciously pleased to grant Her patronage to the Society.

During his submission of the Report the President presented the Guy Medal in silver to Professor M. S. Bartlett and Certificates to the successful candidates in the 1952 examination who were able to be present at the meeting.

On the subject of housing the President announced that the premises referred to in the Report were situated at No. 21, Bentinck Street, W.1. The Society was now completing the contract for the purchase of the lease of the premises.

The Honorary Treasurer, Mr. R. F. Fowler, presented the accounts and seconded the motion that the Report be received.

A discussion of the Report then followed with particular reference to the housing of the Society. Mr. J. Menken was critical, and Mr. A. J. Thayre and Dr. G. H. Daniel spoke in support, of the policy that had been adopted by the Council on behalf of the Society.

On being put to the meeting the Report was formally received, Mr. J. Menken dissenting.

On the proposal of Mr. F. A. A. Menzler, seconded by Dr. J. O. Irwin, Sir Alan Rae Smith was unanimously re-elected Auditor of the Society for the session 1952–53, at a fee of thirty-five guineas.

The President announced that as no alternative nominations had been received, the President, Council and Officers for the session 1952–53, nominated as shown on the list already circulated, were duly elected.

The meeting then terminated.

The Annual General Meeting was preceded by an Ordinary Meeting at which the candidates named below were elected Fellows of the Society:

Lily G. Arumugam.
Arthur J. Boreham.
Bimalesh R. Chaudhuri.
Alfred G. Clark.
Derek Goldberg.
Henry Hayward.
Stanley Hill.
Walter F. Kibble.
Leonard E. Lake.
Isaac A. Mossop.
Ervin G. Muller.
Maurice R. Noyce.
Josè T. da F. Oliveira.
Romuald Slimak.
Clifford Spencer.
Colin F. Stevens.
Gordon W. Taylor.
Jean H. Thompson.
John M. Thomson.

Corporate Representatives.

A. E. Baker, *representing* Chambers' Encyclopædia.
N. M. Khan, *representing* The State Bank of Pakistan.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

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1.—*Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability*. Edited by Jerzy Neyman. Berkeley and Los Angeles: University of California Press, 1951 (London C.U.P.). xi + 666 pp. 10¼″. $11.

This second symposium from the Statistical Laboratory at Berkeley, California, will be as warmly welcomed as the first and pleasure will also be felt at the strong hint of a third symposium before very long. By dint of organization, one of the major troubles which attended the first volume has been overcome: the publication of this second volume has been achieved well within eighteen months from the first meeting of the symposium late in July, 1950. However, the other major difficulty has not been so easily dealt with and this volume is relatively as expensive as its predecessor. These broad surveys of statistical research are so important to the advanced student and the busy practitioner trying to keep abreast of current advances in technique that it is to be hoped that sufficient copies will be available through library facilities wherever they exist.

The second symposium consists of forty-six papers varying in length from ten to twenty-five pages and covering the following attractive range of topics: Mathematical Statistics (13 papers); Probability (14 papers); and Applied Statistics—(*a*) Astronomy, (*b*) Biometry, (*c*) Econometrics, (*d*) Physics, (*e*) Traffic Engineering, (*f*) Wave Analysis (19 papers). A paper by the late Professor A. Wald entitled "Asymptotic Minimax Solutions of Sequential Point Estimation Problems" is accorded first place in the volume as a further mark of respect and sense of loss at his untimely death.

For a volume which is at once so rich and extensive in subject matter, a review can only hint at the detailed contents and reflect the preferences of the reviewer. The usual names are to be seen on the title page: Doob, Feller, Hotelling, Allen Wallis, Hoel, Levy, Cramer, Cochran, Berkson, etc. Stochastic processes are dealt with in at least eight papers and the last two papers on aspects of oceanographic research will be of interest to students of the correlogram. Dr. Berkson's paper on "Relative Precision of Minimum Chi-square and Maximum Likelihood Estimates of Regression Coefficients" might well be read for its delightful presentation—whether or not one is prepared to take sides, or is even interested in the argument. The paper on "A Generalized *T*-test" by Professor Hotelling and that on "Tolerance Intervals for Linear Regression" by Professor Allen Wallis will be of great value for a number of practical problems. These papers are those which particularly appeal to the reviewer and others should not miss the opportunity to browse carefully through the record of the Second Berkeley Symposium although regrettably few will find it possible to have it on their shelves.

W. R. BUCKLAND.

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2.—*The Design and Analysis of Experiments*. By O. Kempthorne. New York: John Wiley (London: Chapman & Hall), 1952. xix + 631 pp. 9″. 68*s*.

The development, mainly by R. A. Fisher and F. Yates, of general principles of experimental design and of many special types of design for particular situations has been a revolutionary advance in scientific method. The new techniques have great possibilities in all those experimental sciences in which the effects under investigation tend to be masked by erratic fluctuations outside the experimenter's control. The book under review sets out to give, for the first time in book form, a comprehensive account both of the general principles and of the detailed mathematical theory of the special designs.

The book starts by attempting to relate the techniques of experimental design to scientific method generally, and then discusses a simple experiment similar to Fisher's tea-tasting experiment. There is next a chapter introducing basic statistical ideas followed by three chapters on least squares. Here the main results are stated, illustrated by examples and then proved by a matrix method. Then two chapters deal with the role of randomization in experimental design, the discussion being first qualitative and then mathematical. Chapters on randomized blocks and Latin squares follow, and there is also a chapter called "Plot Technique" giving a brief account of such matters as the size and shape of plot in agricultural field trials. Nine chapters (about 200 pages) on factorial experiments come next dealing with the confounding and fractional replication of the 2^n, p^n and mixed systems and with split plot designs. There are then four chapters (about 100 pages) giving a remarkably thorough account of the various types of lattice design, and single chapters on balanced incomplete blocks and partially balanced incomplete blocks. The book ends with a chapter on groups of experiments and a short chapter on experiments in which the treatments are applied in sequence.

The analysis of the main types of design is illustrated by worked numerical examples. With the exception of isolated sections requiring matrix algebra, group theory or Galois field theory the mathematics is elementary, although heavy algebra is involved in the analysis of some of the more complex designs, and readers not thoroughly at home among suffices may be in difficulties. The general principles are illustrated almost entirely from agricultural problems and these have dictated also the choice of subject matter, for example the very detailed discussion of lattices.

Several different types of reader will be interested in the book. The statistician familiar with the basic ideas and requiring the theory of the complex designs should find it an admirable reference book. For the student or the reader interested mainly in general principles the book is perhaps rather less satisfactory. The chapters on the basic ideas are not the best in the book and tend to be obscured by detail. The experimental scientist using the advanced designs will probably prefer the much less mathematical companion volume by W. G. Cochran and G. M. Cox, but there is much in the present book that will be useful for reference, for instance the worked examples of the analysis of non-orthogonal experiments and of some of the more complicated lattices. The professional mathematician may find the mathematical parts of the book a trifle laboured. This is as it should be: the author has obviously tried very hard to produce a generally understandable book and on the whole he has succeeded remarkably well, although one would have welcomed a more incisive style.

The most controversial part of the book from a theoretical point of view is probably the discussion of significance tests. Here Kempthorne's attitude is that randomization tests based on permutations of the observations are fundamentally the correct ones, and that the customary t and F tests are justified only as approximations to the permutation tests. The advantage of this approach is that correct significance levels are given under very general assumptions without involving the difficulties about reference sets attendant on the introduction of random variables to represent the residual variation. If in fact the t and F tests are applicable, the permutation tests are asymptotically equivalent to them in large samples. As Kempthorne clearly points out, the difficulty is that the permutation tests are extremely inefficient for small experiments if the conditions of normal theory hold. For example, if there are only N essentially distinct treatment patterns no result can be more significant than 1 in N except by the wholly unacceptable introduction of randomized decision functions. ($N = 24$ for a single 4×4 Latin square.) It would have been helpful to have had some discussion of the recent work by F. J. Anscombe (*J. Roy. Statist. Soc.*, A, **111** (1948), 181) giving conditions under which the t and F tests follow exactly from the randomization. At any rate in such applications as agricultural field experiments where the plot to plot variation can be represented by a set of correlated random variables, often approximately normally distributed, it seems sound to regard the t and F tests as applying even to very small experiments (see Yates, *Ann. Inst. H. Poincaré*, **12** (1951), 97).

For its length the book is comparatively free of minor slips. One of the very few pieces of bad advice is the remark on page 407 that a second test in a fractional factorial experiment should

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be used to re-test the treatments already examined; it will normally be much better to use the extra observations to separate out the aliases of important treatment contrasts.

The book is excellently produced; small criticisms are that the index and cross-referencing are inadequate. Professor Kempthorne is to be congratulated on having produced a very important addition to the books on statistics.

D. R. Cox.

3.—*Grundfragen der Ökonometrie.* By W. Winkler. Vienna: Springer, 1951. xxi + 220 pp. 9″. 32*s*.

What is econometrics? In the sense used, for example, by Tinbergen and Tintner, which now appears to be generally accepted, the term is confined to the application of statistical methods to mathematical economics, with the object of obtaining quantitative relations between economic variables. In the wider sense used by H. T. Davis, it includes more or less all applications of mathematics to economics; but the adoption of this definition makes Davis's *Theory of Econometrics* little more than a rather mixed collection of studies.

The present book is in several ways an improvement on that of Davis, though the author has admittedly been strongly influenced by the *Theory of Econometrics*. Winkler eliminates much material that is either pure mathematical economics, without any reference to statistical measurement, or is out of place for other reasons ; he also contributes valuable critical examinations of the statistical limitations and economic meaning of mathematical relationships. Nevertheless, the book still contains many subjects which would be more appropriate in an ordinary statistics textbook for economists, while on the other hand, important econometric contributions are omitted or given insufficient space.

The book is divided into four parts and thirteen sections, two of which form the first, introductory part. A further two sections introduce the second and third part, dealing with hyperbolic and exponential functions respectively; there is no introduction to the fourth part, dealing with rhythmic fluctuations. Thus, the main body of the book consists of nine sections. But out of these, five are devoted to subjects which are, at most, on the border-line of econometrics: Pareto's Law and other measures of distribution and inequality of incomes; the influence of distance from a city on migration and spread of ideas; growth of population and production; seasonal fluctuations and other regular cycles; the analysis of business cycles. In particular, the space given and importance attributed to Pareto's Law appear to be excessive.

Of the remaining four sections, one which is devoted to the measurement of marginal utility, contains much original work done by the author. Unfortunately, he starts from the assumption that the marginal utility of money is measurable, though the marginal utility of a commodity is not. In consequence, most of his efforts, for example the rather naïve attempt to derive the marginal utility of money from what we might call "the marginal propensity to make donations, at different income levels", seems to be chasing a will-o'-the wisp. Further in this section, family budget data are used to derive the "degree of indispensability" of a commodity group, instead of the simpler concept of income-elasticity of demand.

Another section deals with demand and supply curves but contains mainly an account of the older attempts to measure the price-elasticity of demand. It does not contain a reference to the work of Stone and others who are making simultaneous use of family budgets and time series to obtain both income- and price-elasticities of demand.

Two sections are devoted to relations between factors of production and output. One of them gives an account of Douglas's production function and of some industrial studies, the other some interesting German work on agricultural production. It is a minor fault of the book that these two sections are in different parts of the text, owing to the fact that the sections are grouped into parts according to the predominant mathematical form of the relation and not according to its meaning.

It is perhaps acceptable that the studies of inter-industrial input-output relations originated by Leontief are not mentioned, since they are on the border-line of econometrics only, but an account of the models of an economy constructed by Tinbergen and others should certainly have been included.

These criticisms do not detract from the tribute that must be paid to the author for the achievement of presenting the first textbook of its kind in German. Most of the literature on this subject has so far appeared in the English language, and in the present state of Europe much of the relevant work must have been inaccessible in Vienna. It is hoped that the book will stimulate the study of mathematical economics and econometrics on the Continent, where—except in Holland and possibly Norway—economics has generally stressed the mathematical aspect less than in the case of the Anglo-Saxon Countries. But a study of Tinbergen's book *Econometrics*, for example,

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would help in the selection of subject matter to be included in a book of this kind, and if a revised version of Winkler's book took account of these requirements, it would be even more valuable.

C. E. V. LESER.

4.—*Social Choice and Individual Values*. By Kenneth J. Arrow. New York: John Wiley, 1951 (London, Chapman & Hall). xi + 99 pp. 9″. 20*s*.

This volume, published as Cowles Commission Monograph No. 12, is a highly stimulating contribution to current thinking. It defines rigorously what the social scientist presumably has in mind when he talks of a social welfare function, and shows that this concept is neither as simple nor as unequivocal as some are inclined to believe. Though we have grown more sophisticated since Bentham's days, there is undoubtedly still too much loose thinking in this field and Professor Arrow's book is a useful corrective. The author begins by postulating a relation "preferred or indifferent" to hold transitively for all possible pairs of alternatives. (The existence of such a relation, plausible in itself, has been shown by Houthakker to be sufficient to ensure integrability in the theory of consumer's behaviour.) From this relation a social welfare function is defined as a process or a rule which, given any individual orderings of a set of alternatives, gives a social ordering. This rule, in order to correspond to our commonsense notion of social welfare, should satisfy certain conditions. First, to obtain sufficient generality "every logically possible set of individual orderings of a certain set S of three alternatives can be obtained from some admissible set of individual orderings of all alternatives". Secondly, the social ordering should reflect individual orderings. In simple terms this means that a change in one man's ordering should never cause the social ordering to be changed in the opposite direction. The third condition states that the social ordering should be independent of irrelevant alternatives; e.g., the consideration or neglect of losers among the alternatives should not affect the relative placing of the winners, a condition which is, in general, not satisfied in election by ranking. The fourth and fifth conditions ensure that the social ordering should not depend on the wishes of one individual (a dictator) or a (religous, traditional, etc.) code. The author shows that there exists no general rule such that in no circumstances would one or other of these five conditions be violated. (It is puzzling why the theorem of this non-existence (p. 59) should be called "General Possibility Theorem"). This conclusion, implying that without additional assumptions about individual preferences no voting system nor the market mechanism will yield a rational social ordering, as defined, is surprising. The easiest way out seems to be to drop condition 3 (independence of irrelevant alternatives) where the loss in "reasonableness" of a social welfare function does not appear serious. Another possibility is to reduce the number of alternatives to two-at-a-time, or to consider some other restriction such as the single-peaked variety of individual orderings only as Black has done (cf. V. D. Black and R. A. Newing, *Committee Decisions with Complementary Valuation;* other references in Arrow's book). In the former case we lose not much more than mathematical elegance, while in the latter we obtain definiteness only by a considerable narrowing of our intellectual horizon which one might accept if there were sufficient evidence that individual preferences are, for example, of the single-peaked variety, more often than not. In the last two chapters of his book Arrow discusses these and other considerations, such as the implications of the "consensus omnium"; some of these might have benefited by a more detailed treatment. A further point of interest is this: an individual ordering may (and very likely does) include the process or frame in which social orderings take place. The author's point here is well taken, and it would follow that stability of a social organism depends on the existence of a meta-language of not too high an order, the terms of which are no longer questioned by anyone in a given society. For instance, in a committee voting procedure can be voted upon in an infinite regress, so that for the Committee to act there must exist an accepted method of termination of such a process.

The reviewer has attempted to summarize the contents of this book; it would be difficult to do full justice to the elegance and lucidity of the exposition. The argument uses simple formal logic, and for its understanding nothing but a little patience is needed. The wide range of the discussion provides most enjoyable reading, while its generality makes this a study of importance to the *genus* of social scientist, no matter what the *species*.

G. MORTON.

5.—*Quality Control and Industrial Statistics*. By Acheson J. Duncan. Chicago: Richard D. Irwin, Inc., 1952. xxviii + 663 pp. 9″. $9.

This book is directed towards engineering and business students requiring a first course in statistical methods. It will suit the former group, with quality control engineers and industrial research workers, rather better than the latter. The general class of business students will need a somewhat similar text, e.g., *Applied General Statistics* by Croxton and Cowden, to round off matters such as index numbers and elementary analysis of time series.

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The twenty-seven chapters are divided into five parts—Fundamentals, Acceptance Sampling by Attributes, Acceptance Sampling by Variables, Control Charts, and Some Statistics useful in Industrial Research. Problems (some three hundred and twenty-two in all) are interspersed at the ends of almost all the chapters with a selection of references which will introduce the reader to a valuable range of conditions and up-to-date literature. Indeed, it may do more. Beyond the well organized realm of control charts and acceptance sampling, the statistical tool-box has become stocked with such a variety of tools that the beginner is liable to receive an acute attack of bewilderment when presented with such a vast array of equipment at such an early stage.

The presentation of the material is attractive and there is an appendix to which all mathematical proofs have been relegated: this would serve as excellent revision material for the examination student. A special feature of the lay-out is the rich collection of operating characteristic curves for the various sampling schemes and statistical tests in general use. At the end of the book is a set of tables among which are reproduced, on pages 625 to 627, some by Professor J. W. Tukey given at the 1951 Convention of the American Society of Quality Control, which for some reason did not find their way into the relevant issue of that Society's journal. In addition to the usual author and subject indexes there are a list of symbols used and a short glossary of special technical terms.

This is a book that easily raises enthusiasm only to have it damped on finding that the price is so high that most practical workers will either have to obtain a copy on business account, or queue up with the students for the relatively few library copies that will be available.

W. R. BUCKLAND.

6.—*Application of International Standards to Census Data of the Economically Active Population.* Population Studies No. 9. Population Division and Statistical Office of the United Nations. New York, 1951. 139 pp. $11'' \times 8\frac{1}{2}''$. $1.50.

The U.N. Population Division has in recent years devoted considerable attention to the task of improving the comparability and quality of the data to be obtained in population censuses, especially in view of the number of such censuses taken in or around 1950, and the Population Commission of U.N. and other international bodies have adopted a series of recommendations on this subject. This volume brings together, with explanations and comments, the work done by these bodies on the subject of collecting, classifying and tabulating data on the economic activities of a population, i.e., principally their occupation, industry and industrial status. The recommendations are all given in full in an appendix as well as the standard classifications of industries, and of occupations which have been drawn up by the Statistical Commission of U.N., the seventh International Conference of Labour Statisticians, and the Inter-American Statistical Institute. The term "economically active" (which corresponds approximately to the terms of "occupied" used in Great Britain, or "labour force" used in the U.S.A.) has not yet been generally adopted, nor is the U.N. concept of this term accepted in certain countries.

The chapters on the methods of applying these standard classifications are to be highly commended and should prove of great value to census authorities. The same cannot be said, however, of the treatment of the economically inactive. This large group is discussed primarily from the standpoint of distributing them according to the economic activities on which they are dependent. This question of the dependency of certain individuals on the various activities of other individuals, which is attempted in the censuses of certain continental European countries, usually on the basis of the occupation of the head of the household, is full of difficulties, and such statistics have never been attempted in the United Kingdom or in any non-European country (except Chile). The report mentions the factors which may "have an important influence on the accuracy of the results," and "which may affect their validity." The chief of these is the employment of members of the same household in different industries. Where this is "very common," adds the report, "the result may be a considerable distortion." In spite of these difficulties, the report concludes with specimen tables showing the *total* population classified by dependence on economic activities. One of these "industries (or branch of economic activity)" which is to be divided into "economically active persons" and "dependents of economically active persons" is "unemployed persons who have not previously been employed."!

J. W. NIXON.

7.—*The Cost of Sickness and the Price of Health.* By C. E. A. Winslow. World Health Organization, Monograph Series. Geneva: W.H.O., 1951. 106 pp. $9\frac{1}{2}''$. 7*s.* 6*d.*

This memorandum was written as the basis of a discussion on the economic value of preventive medicine at the Fifth World Health Assembly. The care of the poor and sick, if it is not to go by default, must be a charge on the prosperous and healthy. Wealth and health are closely correlated,

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as has been abundantly illustrated by so many medico-social workers, that it is possible to treat "poor" and "sick" as synonymous in relation to public health needs at the risk of some looseness of definition. The prosperous, however, need to be convinced that the care is real and the cost reasonable; first in the sense that the measures taken are efficacious and cheaper than any equally efficacious measures, and secondly in the sense that the economic burden they impose can be fitted into their general economy without placing them at undue commercial disadvantage in a competitive world. Professor Winslow, who knows full well the ideology of hard-headed, though not necessarily hard-hearted, business men, sets out to carry this conviction. Within this context the main thesis is that "prevention is not only better than cure, it is also cheaper." The economic value is at once a political value too, for "To-day men realize that the united world which they desire to build cannot be established and maintained by constituent nations handicapped by overwhelming burdens of poverty and disease". The material view of matters of life and death which Professor Winslow accepts in order to carry the fight to those who may begrudge expenditure on health services can be a little cold, as when we read that certain "U.S. studies indicate that . . . a death at 15 years or under represents a net economic loss to society; that a death at the age of 40 represents a net economic gain; and that a death at 65 represents a net gain more than twice as great", or that "Nations like Sweden and the U.S.A., which have been able to make the relatively small investment involved in a sound public-health programme, have reaped a rich harvest in life capital as a result". Nevertheless there is no escaping the fact that "preventable disease imposes a heavy burden in the loss of productive power". Estimates of this burden in different countries, in hard cash, which are quoted from various sources do indeed add up to staggering dimensions.

Professor Winslow then goes on to show from a review of achievements that "the heavy burdens of disease can, in large measure, be lifted by application of scientific knowledge already available; and each year the results of public health research are broadening the area of possible control". The history of achievement is indeed rich in example—the conquest of typhoid and waterborne diseases in Latin America, the control of louseborne disease in Afghanistan, the eradication of malaria in Chile, the considerable progress against tuberculosis in Western Europe and the U.S.A., the widespread reduction in infant mortality, to mention only a few. In keeping with his thesis Professor Winslow measures all these achievements in terms of reduced absenteeism and greater production. "In Haiti, where yaws is widely prevalent among the rural population, 35,000 to 55,000 persons have been treated monthly in a joint WHO/UNICEF treatment campaign. It has been estimated that by this simple programme 100,000 incapacitated persons have been returned to work, increasing the national production of Haiti by $5,000,000 a year." The author is not content with the prevention of disease, but goes on to speak of progress in the promotion of positive health; improved nutritional standards, better housing and the protection of the well-being of the worker in industry.

The essential components of a national health programme are discussed in some detail in relation to the universal needs to be met at national and at local levels. A danger is the possible lack of balance between preventive and curative services; the former often tends to be neglected in favour of the latter. There is the attendant problem of total physical facilities. "Curative medicine of an effective scientific type must rest on good hospital facilities as its basis; and preventive medicine must depend in large measure on outpatient services for the ambulant case and on centres for health promotion through individual instruction in the principles of personal hygiene." Presumably Professor Winslow would include, in these preventive services, general practitioner manned health centres for the detection of incipient departure from normality. He agrees and indeed argues that there is a lot to be learned about the optimum use of these facilities, particularly in the direction of closer integration between hospital and preventive services. The cost of these components of a health service is then assessed. "In the more prosperous areas it has been estimated that a purely preventive programme can be financed at a cost of about 0·5% of the national income, while curative medicine requires an expenditure of ten times that amount." Professor Winslow thinks this type of estimate gives a false criterion of the needs of under-developed countries where the cost of essential health work goes up as the income goes down, and suggests that the least fallacious criterion would be the expenditure per capita for a given area; in the U.S.A. this approaches $4·00 *per capita* per year—the average income per person for some two days, but this excludes the cost of medical care insurance (a commercial, not a public, service) of $40 a year per person. The National Health Service cost may be compared at £8·6 *per capita* per year. It must be admitted that costs of *actual* services are only partially successful in assessing the cost of *ideal* services. Professor Winslow prefers not to guess, and calls for careful statistical study of the cost of a programme as nearly approaching the ideal as the economic resources of a given country may permit. It may then be found necessary to approach this ideal by stages of relative priority.

Professor Winslow underlines his plea for purchasing health by discussing the role of poverty in the causation of disease, and the economic aspects of the application of a health programme.

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Criticism of preventive medicine, on the grounds that it leads to over-population and hunger, is met by stressing the dividend of higher productivity, but the author does urge that the health administrator "must sit down with experts on agriculture, on industry, on economics and on education and integrate his specific health programme as a part of a large total programme of social reconstruction."

Finally—his ultimate objective—Professor Winslow calls for unstinting technical assistance to be given by the more fortunate to the less fortunate sister-nations. "The stable world order of which we dream can be built only on the foundation of Member States in every one of which there is at least a reasonable hope of progress toward freedom from disease and want—as well as from fear."

This is not a lengthy monograph, but it is remarkably full of facts and rich in both experience and stimulating thought. It is more than a timely stocktaking, on a global scale, of human effort for human good: it is a serious challenge to those who live in the present to be concerned about the future before it is too late.

B. BENJAMIN.

8.—*Internal Migration.* By Mary P. Newton, M.A., and James R. Jeffery. General Register Office: Studies on Medical and Population Subjects No. 5. London, H.M.S.O., 1951. 44 pp. 9½". 1*s.* 6*d.*

The essence of planning for the community is the effective anticipation of human want—on a social, not on an individual scale. The statistical foundation of planning on this wider front is as valid as the statistical basis of planning on a narrower front, such as in personal life assurance or even in family budgets. Many people find planning abhorrent because their attitude is prejudicially an individual one: a reluctance to accept a suggestion that they personally will behave in a certain way at a certain time. No such individual forecast is, however, implied. No planner knows, or cares, whether Mr. Robinson intends to catch the 5.18 train out of Euston to-morrow, but he does know from statistical distributions of passengers, in the plural, that the number of occupied seats on the 5.18 is unlikely to exceed so many or be less than so many. Let it be emphasized, however, that the statistical distribution, the prior fact finding, is fundamental.

In the planning of housing or industrial development, in attempting to design on the one hand an efficient agricultural economy and on the other the optimum location and size of industrial and commercial resources, much depends on a knowledge of internal distribution of population and of the factors which may influence the pace and direction of changes in that distribution. The present study is an examination of these changes so far as is permitted by information directly available to the General Register Office.

Part I of the study deals with the broad trends of population changes within the country since the Industrial Revolution. The main sources of information have been the successive censuses, held decennially (except in 1941) since 1801, and the registrations of births and deaths which have taken place since 1837. The censuses show, for each census day, the numbers of population in each local administrative area; and thus the extent of the inter-censal increase or decrease of population can be calculated. The registrations enable the natural increase (the number of births less the number of deaths) to be calculated for each area. Any difference between these two figures must be due to migration into or out of the area. This migration figure, however, is only a balance (net migration), relates to intervals of not less than ten years, and gives no indication of the separate total outward and total inward movements of population for each area, or of the sex and age of the people moving or of the paths of the separate movements.

The National Register, which was set up in 1939, made available much more information. It has provided a precise record of the contemporary movements each year into and out of local administrative areas (boroughs, and urban and rural districts). Part II of the study discusses the value and limitations of this information, and provides some preliminary results. It is noted, for example, that during 1948 and 1949 some eight million moves between these areas took place: there were, in addition, millions of cases of "house-moving" within the boundaries of the local areas.

A more detailed analysis is made of 27 areas, specially selected to represent particular types of circumstances and particular types of planning problems, e.g., Coventry, a town attracting engineering skills; Wortley Rural District, a locality destined to receive large numbers of people moving from Sheffield to less congested areas; Worthing, a town attractive to elderly and retired people; Corby, a designated new town where expansion has already begun and to which people of working age will tend to move. The different circumstances determine the age and sex contour of the migrant population, and this is clearly brought out by the analysis.

In discussing the possible restrictive influence of the housing shortage it is emphasized that the annual volume of migration is out of all proportion to the yearly provision of new housing accommodation, so that most of the movement is into accommodation made available by rearrangement of existing occupation—and houses are packed more tightly in recently expanding areas than in others.

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The impressions from this necessarily limited survey are succinctly stated in a single paragraph: "Although the evidence consists only of partial information about supposed characteristics so that general inferences must be speculative, when it is taken as a whole a picture begins to emerge. It depicts people as being specially mobile at early adult ages before they have become settled in their trades and professions (though not before they have developed leanings to particular occupations), and in many cases before they have got married or started to rear families. It suggests movement inspired by prospects of better jobs elsewhere in chosen occupations . . . . . The evidence also suggests changes of homes without changes of jobs in decongestion movements, in suburban expansions, and in movements along the lines of daily journeys to work".

The report is a useful contribution to the pool of information required for town and country planning, and is more valuable for having been compiled in such a workmanlike manner and in such a digestible form.

B. BENJAMIN.

9.—*Manpower Resources and Utilization.* By A. J. Jaffe and Charles D. Stewart. New York: John Wiley (London : Chapman & Hall), 1951. xii + 532 pp. 9½″. 52*s*.

It is comparatively rare for civil servants to sit back and generalize about their job; and for this reason alone any book on their own field by those who have served as Government statisticians is likely to be of some importance. Moreover, when the authors are American and their field is that of manpower statistics, the present discontents—the exigencies of social policy in general and of industrial mobilization in particular—guarantee to the British reader a strong topical interest in their work.

Since 1940, what are officially known in the United States as "labor force" statistics have been collected monthly by the Bureau of the Census on the basis of a sample of some 25,000 households (or 1 in 1,600), the occupation and precise employment status of each individual of 14 years or over during a given week being recorded. This procedure differs of course from that used in the British statistics of "total manpower" by industries, which are based on the exchange of National Insurance cards every quarter and adjusted monthly from direct employment returns. Jaffe and Stewart, in *Manpower Resources and Utilization*, begin by examining the differences in conceptual approach which give rise to different methods of enumeration, and explain in general terms how these different concepts correspond with the needs of different forms of society: "two mutually related factors—the economic structure of the society and the social purposes to be served by the data—will determine who will be included in any measure of the working force in any place or time"—or indeed whether it is measured at all. Whereas in the U.S.A. detailed information is needed on many aspects of social and economic behaviour before appropriate action can be taken, in a primitive economy "no one intends to take any action, and therefore data that could help decide the nature of the specific action called for are unnecessary."

The book naturally deals in considerable detail with American statistics, and the central—and most valuable—section consists of a careful analysis of the structure of the U.S. working force by age, sex, colour, urban-rural composition, marital and family status, industry and type of occupation, together with an examination of turnover. As far as possible, the changes in structure are then traced back over time, so as to illustrate the historical development of the present-day working force. Many features of this development—on the one side, the increased proportion of women, technicians and white-collar workers, and on the other the decline in the proportions engaged in agriculture and in the production of physical goods in general—are of course well known and common to most industrial countries. But the detailed information on the size and shape of the changes, the care with which the data have been used, and the important qualifications which emerge, amply justify the undertaking; and the authors' experience and confidence in handling the material results in an interesting commentary which, with a short introduction and a technical appendix on enumeration procedures, might well have stood on its own as a separate study.

The ground chosen is, however, wider than this, for the writers are concerned with the *raison d'être* and justification of manpower statistics in general and with the changing needs that determine the form they take, and are therefore also interested in making comparisons with other countries. The result is that the 112 pages on the American scene are prefaced by 118 pages on the problems of measurement and analysis, and followed by a further 180 pages on the working force in its social and economic context. This involves a disquisition on the general character of technological development and its effects on productivity, leisure, the emergence of new occupations and skills, and employment as a whole; some discussion of the effect on the labour force of demographic factors, and of migration both within and into the country; and a chapter on social and psychological aspects of the working force, in which the attitudes to work prevalent in industrialized and non-industrialized societies are compared. This leads on to a concluding section

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on the working force in its "cultural context", in which twenty-nine countries are divided into three groups according to the proportion of old men (65 and over) who normally go out to work. From this we learn that the inhabitants of the countries where this proportion is highest have, per head, a lower income, less mining and manufacturing, fewer cars and telephones, fewer doctors and a higher birth and death rate, more agricultural workers and less food, fewer school teachers, more illiteracy and less mail. The book is then rounded off with 84 pages of appendices (excluding tables), on topics such as the Bemba of Northern Rhodesia, the detailed procedures of the U.S. Bureau of the Census, the influence of attitudes upon the collection of working force statistics, the tobacco processing and manufacturing industry in the United States, and experience with labour force procedures in Puerto Rico and Japan. Seven of the twenty-one chapters and one of the ten appendices have summaries, usually at the end but occasionally in the middle. So very broad a landscape deserves, to say the least, better signposts.

No one can deny the relevance of much of what is said: the tree of economics has many branches, and other sciences of human behaviour belong, no doubt, to the same forest. But—to spare the reader as well as to ensure that the treatment does not occasionally become superficial—selection must be made, and this the authors have not always had the heart to do. It is true that they sometimes feel obliged to refer to what they are leaving out: "we have not attempted to draw an over-all picture of working force 'conditions' throughout the globe"; "to give an adequate explanation would require a complete theory of social, economic, and cultural development, an exposition of which is beyond our present scope". But few people would have expected to find such a complete theory in a book of this kind.

Nor does the theoretical aspect of the book, when it emerges, always seem to justify the space given to it. A section headed "Preindustrialized versus industrialized societies, or subsistence versus market economies" opens as follows: "a central thread running throughout this book is that the transformation of a society from a primarily subsistence economy to a market economy results in the formation of a modern working force". Evidently; but "since it is beyond the scope of this book to encompass all factors that are related to the historical development of specific areas or that would be part of an all-inclusive theory of social change", the concept of a "modern working force" is soon qualified by the phrase "in a free society". This qualification by itself, of course, precludes consideration of the U.S.S.R.; but it is strange to read that "if we are concerned as we are in this book with an analysis determining the formation of the working force in *any* society, we need only say that in such totalitarian societies the decisions are made by State authority, not by the interplay of social and economic forces upon the individual. There is, in short, no phenomenon to be explained by scientific analysis". But are the boundaries of scientific analysis—except perhaps in the U.S.S.R. itself—to be determined by political teleology?

Yet although to an English eye the book may read somewhat cumbrously and verbosely in places, its very discursiveness, and its tendency to quote and to summarise, should make it useful as a reference book for readers who have limited access to American sources. Nor should its faults of construction blind one to its virtues, for so comprehensive an analysis of U.S. manpower statistics is both interesting and of evident value, and we should not complain overmuch if two experts who write with authority on their own subject are inclined to be a trifle expansive, and occasionally to labour the obvious, when they roam in neighbouring fields.

K. G. J. C. KNOWLES.

10.—*The Urban Working-Class Household Diet* 1940 *to* 1949. Ministry of Food. London, H.M.S.O., 1951. vi + 114 pp. 9½″. 3*s.* 6*d.*

This is the first report to be published on the results of the National Food Surveys which have been carried out by the Ministry of Food continuously since 1940. It contains a general account of changes in food consumption by urban working class households in the years 1940–49, together with a brief description of the methods used in collecting the data. Further reports, at present in preparation, will contain information about food consumption by different social classes, and in different geographical areas, and also about expenditure on food.

The original purpose of these Surveys was to provide the factual background which was required for the formulation and for assessing the effects of the government's war-time food policy. But as food supply problems did not disappear at the end of the war, and as new problems arose—in connection, for instance, with derationing—there was an obvious need to continue the surveys after the war. The information given in this report shows how necessary the National Food Surveys must have been in helping to maintain nutritional standards during the war. Indeed there is much to be said for the regular collection, even in more normal times, of such basic information on economic and social conditions.

It is obvious that on the whole the surveys have been very efficiently carried out and the present report, which has been prepared by Mr. W. L. Kendall and Miss D. F. Hollingsworth, provides

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an admirable account of some of the main findings. It also includes a convenient summary of the comparable results of the various pre-war surveys, including some figures which have not previously been published.

The comparability of the several war and post-war surveys has, unfortunately, been impaired by periodical changes in the composition of the samples. Some of these changes were, needless to say, unavoidable during the war. But in most cases it would be possible to estimate, or to eliminate, the effects which they had on the results. Up to 1944, for instance, the samples were confined to areas which were predominantly working class, but afterwards they were extended to mixed middle and working class areas; the figures for the later years therefore include working class households (defined according to the occupation of the head of the household) living in these "mixed" areas. As such households are likely to be better off than other working-class households, separate figures could have been given for households living in predominantly working-class areas, which would have been comparable with the results of the earlier surveys. The only factor for which the results appear to have been adjusted is the changing representation of areas where bread is frequently baked in the home.

One rather curious result of these surveys is that the stocks of food held at the end of each week for which detailed records were kept were generally found to be higher than the stocks held at the beginning of the week. This applies to practically all foods (with the exception of sugar) and to all periods of the year. In consequence estimates of consumption which allow for changes in stocks are generally higher than estimates based on purchases alone. The only explanation for this which is offered is that "it was due presumably to a tendency for housewives when taking part in the Survey to purchase rather less than their usual quantities during the survey week owing to the time and trouble involved in keeping the records". But the curious thing is that the tendency applies even to the most perishable kinds of foods. The "consumption" figures (taking account of stock changes) of liquid milk, meat, bacon, fresh fish, eggs, tomatoes, even of bread, and even of fried chips are higher, in almost every year, than the corresponding figures of purchases. In only a few of these cases can the difference be explained by home produced supplies—obtained from farms or allotments—which are apparently included in the "consumption" figures. If the explanation which has been offered were correct, one would expect tinned and preserved foods and sugar to show larger discrepancies than fresh and perishable foods: but this is not generally the case. It would also be interesting to know whether the discrepancy was highest in households which possessed the largest quantities of stocks. Usually, of course, the difference between the two figures is fairly small; for food as a whole it is about 5 per cent. But from a nutritional point of view such a difference cannot be considered negligible, and the problem appears to call for further investigation. It is probably more difficult, even with the assistance of the investigator, to obtain accurate records of stocks than of purchases. And the average quantities purchased by large numbers of households over extended periods would be expected to agree with the average quantities consumed. It is not certain, therefore, which set of figures is likely to provide more accurate estimates of consumption.

It is difficult, of course, short of recruiting ghosts as interviewers, to find out the effects of the survey itself on spending and consumption. But experiments could, perhaps, be tried with records for varying periods of time; and it might also be worth trying to collect some information (e.g., about purchases in the previous week) by means of oral questionnaires.

The selection of households followed the well-known and generally accepted principles of two-phase (or three-phase) random sampling, except in one particular. Each investigator worked in cycles of 10 days and attempted to obtain completed record books from 10 households during each cycle. If, after two days, the investigator had not obtained the co-operation of any of the households in her original list, she tried to complete her quota by substituting the next house to the right, or, if that failed, the next but one to the right, and so on. There was thus added to the original list of households selected by random sampling an admixture of households selected by the method of quota sampling. In practice substitute households, selected in this way, appear to have formed about half of the final sample. The claim that there was little difference in the expenditure habits, or in other characteristics, between the households in the original list and the substitute households is easy enough to accept. But why, in that case, go to the trouble to obtain substitutes? The effect of including them is not to remove, but simply to reproduce, any bias resulting from the fact that it is not possible to obtain the co-operation of all the households in the original sample. As a result there was a larger proportion of children in the households for which records were obtained than in the population generally; again, some adjustment could perhaps have been made for this in the estimates of average consumption.

Up to 1944 the surveys were confined to working-class households living in predominantly working-class areas, and in most years they were confined to urban districts. From the beginning of 1944 the surveys were extended to cover middle-class households and in 1950 they were further

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extended to cover all classes of the population in both urban and rural areas. A great deal of the interest and importance of the surveys depends on being able to compare the figures for different classes of household, as well as for the same class of household at different dates. The present report is confined to comparisons of the average consumption of urban working class households at different dates. It is also, of course, interesting to know the distribution about the average. If, in fact, the distribution is very uneven, the average by itself may not have much significance; it is for this reason that, in certain cases, the averages have not been given. The same limitation applies, however, in varying degrees, to all averages; provided that this limitation is always recognized, they may still be of interest. But many of the more interesting conclusions will only emerge when the full detailed results appear in the further reports which have been promised; it is to be hoped that they will appear fairly soon.

Although criticisms on minor points are possible, there ought to be no doubt at all about the importance of these surveys. They have been carried out, and the report has been written, in a thoroughly objective and impartial spirit and it is most desirable that surveys of this kind, covering the whole population, should continue to be undertaken regularly.

J. L. NICHOLSON.

11.—*Durée de la Vie Économiquement Active Suivant la Mortalité.* By Giorgio Mortara. Rio de Janeiro: Servico Gráfico do Instituto Brasileiro de Geografia e Estatistica, 1951. 29 pp. 10½″.

The mortality trends in forty different populations in the world are analysed to reveal a general increase in survivorship from birth to the beginning of active working life (assumed to be age 15), and an even greater improvement in survival to the end of active working life (assumed to be age 60); or to put it in another way, a significant decrease in mortality before age 15 and an even greater decrease in mortality between ages 15 and 60. For a generation of births the expectation of life between these two ages has increased, and has increased approximately in proportion to the improvement in the total expectation of life at birth. Thus the increased productivity of a generation is to some extent outweighed by its longer expectation of survival in the unproductive years of old age. It may be, however, that improved mortality is synonymous with reduced morbidity and enhanced activity at older ages, so that the age of termination of active working life may safely be advanced beyond 60.

The conclusions drawn from this study can hardly be regarded as new, since they have become commonly accepted in economic and demographic discussions of problems of ageing populations, but the paper is of considerable interest in so far as it brings together mortality statistics for a large number of different countries as far apart as Sweden and Salvador, Norway and Mexico, and demonstrates considerable uniformity in the proportion of total life expectation (about 60 per cent.) lived between ages 15 and 60.

B. BENJAMIN.

12.—*Studies in Income and Wealth*, vol. 14. *Conference on Research in Income and Wealth.* National Bureau of Economic Research. New York, 1951. x + 276 pp. 9″. $3.50.

This book contains a selection of papers, and comments thereon, delivered at a Conference in April, 1950. As the previous volume confined its attention to the distribution of income, so in the present work all the papers deal with some aspect of the problems of wealth, principally its measurement. The manner in which this record of proceedings differs from its predecessor is possibly instructive. It is much more modest in size, thus perhaps reflecting the fact that the field with which it is concerned has suffered from too little attention in comparison with the crowded and churned-up income arena. Secondly, some slight attention is paid both to economic theory and to the empirical determination of the influence of wealth on economic behaviour. Once again these inclusions may be taken as indicators of the lack of an accepted body of doctrine dealing with such problems.

It is perhaps surprising that the compilers of the conference record should have chosen to present the papers in an order which is almost the reverse of the logical. Theory comes last and measurement first. To the reader outside the United States the last two papers by L. R. Klein and K. E. Boulding make a much deeper appeal than the earlier and more parochial efforts, which must be waded through first, at any rate by a reviewer.

The conclusions of Professor Boulding's paper on "Asset Identities in Economic Models" clearly took its critics by surprise, and although they were of one mind in maintaining an obstinate conviction that something was wrong, they were not successful, either singly or collectively, in putting their fingers on the trouble. This paper in a slightly amended form plays an important part in Professor Boulding's book, *A Reconstruction of Economics* (New York, 1950); indeed in his preface to this work he claims that he has at last provided a "macroeconomic theory of distribution commensurate with . . . [the] theory of employment". He adds, too, that this "is perhaps

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the most original and controversial section of the work". In March, 1952, however, Mr. J. Johnston pointed out in the *Economic Journal* (vol. 62, pp. 184–191) that Professor Boulding's startling results arose from his confusion between the gross and net forms of his so-called Business-Net-Worth identity.

The paper entitled "Assets, Debts and Economic Behavior" is an account of a statistical investigation using the data thrown up by the Federal Reserve Board's Survey of Consumer Finances. Klein's treatment of the problem seems to me to be a model of what such things should be. The effect of liquid asset holdings and of debts of various sizes on consumers' behaviour is at the same time a fascinating problem and also of tremendous practical importance. A man of Klein's theoretical and statistical skill is clearly just the person to tackle the task. What is more, he is capable of communicating his enthusiastic interest in the subject to the reader virtually without loss. His work alone provides an indisputable justification for the collection of more detailed information about the structure of individuals' assets and debts.

Even with Klein's ingenuity in the mind's eye, the other papers on the measurement of wealth seem a rather dreary lot and, as has been indicated earlier, the beginning-to-end reader will not be fired with the necessary enthusiasm until too late. Pride of place is given to Raymond W. Goldsmith's "A Perpetual Inventory of National Wealth". The monumental task to which he has addressed himself is the estimation of the National Wealth of the United States in real terms since 1896. So far as reproducible tangible assets are concerned, Goldsmith cumulates depreciated capital expenditures so as to obtain the replacement cost of the existing capital stock at either current or 1929 prices. For non-agricultural land the ratio of the value of the land to that of the structures thereon was estimated from information provided by lending institutions and then applied to the value of the structures, as obtained by the cumulation of depreciated capital expenditures. This, as he readily admits, is a pretty hazardous method of estimation.

Lurking behind the immense industry that these compilations must have involved is Goldsmith's desire to provide sufficient data for a national balance-sheet to be drawn up annually and placed alongside the other social accounts. While it is possible to be attracted by the formal tidiness of such a presentation, some economists may be dogged by persistent doubts whether the accounting conventions appropriate to the balance-sheets of individuals and firms can necessarily be usefully employed for a whole nation. The fact that social accounts have proved so valuable surely rests upon the fact that they portray actual money-flows. A balance-sheet, on the other hand, requires the *valuation* of assets; and the appropriate method of valuation may well not be the same for a firm as for a large country. No convincing answer one way or the other can be given until the precise uses of a national balance-sheet in the formulation of economic policy have been clearly set out.

Rather different doubts seem to have worried Professor Kuznets. In his comments he expressed the view that in measuring national wealth the emphasis should be placed rather upon wealth as a productive tool than on its replacement cost. He also emphasized that depreciation allowances, however calculated, involve prediction about the uncertain useful life of existing assets.

The next paper on "The Post-war Structure of Financial Claims" by Daniel H. Brill does not really live up to its promise. Brill's purpose was to analyse the private debt structure existing in the United States in 1946–8 compared with 1939 and to estimate the vulnerability of debtors in an emergency, especially the extent to which a fall in incomes might tend to be aggravated by the present structure. His information naturally tended to be fragmentary, but broadly speaking the position appeared to be more favourable in 1948 than in 1939. However, it is disappointing to the reader to get so little out of the analysis.

The remaining three papers deserve only the briefest mention. In "Measuring Estate Tax Wealth" Horst Menderhausen and Raymond W. Goldsmith attempt to estimate the wealth of the top percentile of individuals in the United States, using the details of the estates of the dead as given by Estate Tax returns. They make use of death-rates obtained for the Metropolitan Life Insurance Company in order to overcome the difficulties arising from the lack of wealth-specific mortality-rates. They also enumerate the further information that is required if this kind of exercise is to be really successful.

Dwight B. Yntema's "Review of the 'Composition of Estates Survey'" seems to be of scant interest except in so far as it provides lessons of the way in which surveys should not be conducted. The conclusions could be adequately covered without the wealth of detail actually given. "Using Assessed Valuations in Wealth Measurement" by Allen D. Manvel deals with the problem of converting the assessed value of real property into an estimate of its current market value. He recommends the use of sampling methods in order to obtain the ratio of market to assessed values.

To sum up, this latest volume of *Studies in Income and Wealth* is of variable interest and quality. One reader at least would prefer more succinct presentation and the coverage of a rather wider selection of topics that such a treatment would make possible.

A. D. Roy.

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13.—*The Sterling Area.* By A. R. Conan. London: Macmillan, 1952. viii + 192 pp. 8½". 16*s.*

Although the figures in this book are treated as simply as possible, statisticians who have had to cope with the difficulties of assembling material relating to a number of different territories will find this work of no small interest. With so much information not available, some not freely interchanged (not even between governments, as Chapter V hints was once the case), and the rest scattered far and wide, it is no mean feat to have written tidily upon an untidy subject and to have produced a book upon the sterling area at all.

The object is to present a factual account of the sterling system in the post-war years so as to set out the external position of each member separately and also as part of a whole. It is refreshing to find that the dollar problem is not taken as overshadowing all the rest but is seen in perspective. While much has been extracted from existing sources or patiently tracked down in the publications of the separate countries, there is a certain amount of original material, or of facts set out in such a way that the information conveyed is virtually new. Especially valuable is the chapter on The Capital Account. Mr. Conan does not take refuge in residual items as a substitute for intelligent estimates of capital investment, and reviews independently the transactions of the principal countries. In the useful table on page 121 and in the first Appendix, the value (as distinct from the nominal amount) of this country's direct and quoted overseas investments is put at rather over £4,000 millions in all. When taking into account other assets and the sterling balances and other liabilities, the U.K. appears to be a net debtor as at 1950 to the extent of under £1,000 millions —which is hardly a crippling burden—and is a substantial creditor on investment account. While the reasoning behind some of the individual estimates is not always fully enough explained to be convincing, the picture as a whole seems fair.

Mr. Conan shows that our long-term investments have been restored to almost the pre-war position partly by the rise in value of our remaining interests and partly by the substantial post-war flow of new funds to the rest of the sterling area. But it is doubtful whether it is really worth while at this stage to demolish the old arguments about our lost assets, as advanced in the White Paper preceding the Washington loan negotiations. "Unrequited exports" (a phrase that seems to be avoided, though the absence of an index makes it hard to check this and various other points) are also held to have been much less extensive than the public, if not economists, supposed. The importance of prices in the shifting centre of gravity within the sterling area is true enough, though the problem is after all substantially the same as the changes in the terms of trade about which there has already been much discussion. Readers may be somewhat startled by the statement, cautiously phrased as it is, that "when all factors are taken into account, there seems some evidence to support the view that the balance of payments of the United Kingdom after the war might be considered fundamentally more satisfactory than in 1939".

The book is logically arranged, the sections well balanced, the tables simply presented and the arguments clear. In spite of the claim to be merely factual, there are many interesting pages on developments in policy and on the mechanism of the system and the strains set up within it.

Lack of detail, however, will hamper the reader who regards this book as a starting-point for the further study of particular problems. Notes and references are given so sparingly that it is sometimes hard to see how the tables obtained from different sources tie in with each other. There is little attempt to tackle the difficult question of relating trade and financial statistics to one another. It would, moreover, have been useful to have more quantitative information about the commodities so important to individual members of the system. The Colonies are grouped together, though some distinction between the economies of, say, Malaya and the West African territories might reasonably have been expected. Southern Rhodesia is separately discussed, but not Northern Rhodesia with its copper mines. It is, too, not explicit where imports are recorded c.i.f. and where they have been adjusted for freight, and a brief footnote on this subject is not enough if visible and invisible items in the overseas balance are to be contrasted.

The world of officials says little about its methods of obtaining accurate data on the balance of payments of different monetary areas, and while statisticians are acutely conscious of the many difficulties that remain they will on the whole welcome Mr. Conan's clear account of the financial framework of the sterling area.

M. S. Rix.

14.—*Other New Publications*

National Income and Expenditure. By J. E. Meade and Richard Stone. 3rd ed. Cambridge: Bowes & Bowes, 1952. 48 pp. 7¼". 3*s.*

The periodic estimates of national income and expenditure are now habitually used by students of the national economy and are widely quoted. As long ago as 1940 there was an evident demand

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for a simple introduction explaining the various concepts on which the estimates are based and the nature of the figures themselves, and this was met by the first edition of this pamphlet, now re-issued with textual revisions, up-to-date figures and additional sections. To those to whom the estimates are unfamiliar (as they must be to, e.g., young students) this introduction should be of great service; more experienced investigators will also be glad to have it for reference on points of uncertainty.

Advertising Expenditure in 1948. By Rodney Silverman. London : The Advertising Association, 1951. xi + 99 pp. Illus. $9\frac{1}{2}''$. 21*s*.

Advertising is a cost of distribution much subjected to criticism, and it is of general interest to have this analysis of the actual expenditure incurred, and of its relation both to the revenue of various trades and industries and to the national income as a whole. The Research and Statistics Committee of the Advertising Association, with the technical advice of Mr. W. B. Reddaway, set a detailed enquiry on foot in 1949 and achieved a remarkable degree of co-operation from the associations, firms and individuals approached. The report on the results obtained has been prepared by Mr. R. Silverman, who, with Mr. N. Kaldor, had produced a pre-war survey of advertising. All engaged in business research will find the account of sources and methods of estimation useful, whether they are primarily interested in the detailed tables or not.

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STATISTICAL NOTES

(1) British Official Statistics

The interim index of retail prices published by the Ministry of Labour and National Service which stood at 135 (prices at June 17th, 1947 = 100) rose to 138 in June and remained at that figure in July. The rise was due mainly to higher prices for meat and tea, but there was a slight fall in the prices of some clothing and household textiles. Separate figures on the same basis for different groups of commodities are not available, but the following are the figures based on January 15th, 1952 = 100:

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Household Durable Goods*	*Miscellaneous Goods*	*Services*	*Alcoholic Drinks*	*Tobacco*	*All Items*
Weights:	399	72	98	66	62	44	91	78	90	1000
May 13th	104·4	102·3	99·1	99·6	99·4	103·4	102·7	100·8	100·0	102·2
June 17th	108·7	102·5	97·9	100·7	98·7	103·7	103·1	100·8	100·0	103·9
July 15th	108·5	102·6	97·0	100·9	98·2	103·7	103·1	101·2	100·0	103·8

The Ministry of Labour index of weekly wage rates which was 129 (June 30th, 1947 = 100) at the end of May remained at that figure in June and July. There were increases in rates of wages in a few industries, including iron and steel, milk distribution, and printing, but these were insufficient to affect to a whole number the average level in all industries combined.

The total working population and the numbers in civil employment in the three months ended June were as follows:

Thousands

	Total Working Population			*Numbers in Civil Employment*		
	Males	*Females*	*Total*	*Males*	*Females*	*Total.*
April, 1952 . .	16,051	7,429	23,480	14,958	7,176	22,134
May, 1952 . .	16,055	7,428	23,483	14,970	7,182	22,152
June, 1952 . .	16,023	7,413	23,436	14,950	7,191	22,141

The number of persons on the unemployment registers of the employment exchanges fell by 27,000 in June and by a further 7,000 in July. The total, of 393,464, at July 14th represented 1·9 per cent. of the estimated total of employees. The percentages in the separate regions ranged from 0·9 in the Midlands to 3·2 in Scotland and 3·9 in the North-West.

The following is a sex analysis of the figures :—

Numbers of unemployed persons on the registers of employment exchanges

Date	*Men and Boys*	*Women and Girls*	*Total*
May 12th, 1952 . . .	235,167	232,278	467,445
June 16th, 1952 . . .	223,082	216,972	440,054
July 14th, 1952 . . .	209,938	183,526	393,464

Of the total of 393,464 at July, 14th, 101,077 were temporarily stopped, 83,042 had been unemployed for not more than two weeks, 77,020 for 2 to 8 weeks, and 132,325 for over 8 weeks.

The number of insured persons absent from work owing to sickness, including self-employed as well as employed, was 811,000 in May, 769,100 in June and 754,500 in July. The number of employed persons absent owing to industrial injury was 55,700 in May, 52,500 in June and 53,200 in July.

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Statistics relating to the employment of married women, based on a sample of the insured employees, are given in the *Ministry of Labour Gazette* for August. It is estimated that at May, 1951, 3,070,000 married women were in employment, about 43 per cent. of all female employees. The percentage varied from 32 per cent. in Wales and Scotland to 50 per cent. in the Midlands. An industrial analysis shows a relatively high percentage of married women in cotton, pottery, wireless apparatus, entertainments and catering. In clerical employments the percentage is relatively low.

Census 1951—*Classification of Industries*.—This list of orders, standard industrial classification and census units, together with an alphabetical list of industrial terms giving the appropriate census code number for each is indispensable to users of the industrial and occupation volumes of the 1951 Census of Population. The introductory text makes clear the distinction between the terms "occupation" and "industry," so often confused; explains the Standard Industrial Classification which, with some modifications in detail, was used in 1951, and describes the coding practice of the 1951 Census.

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(2) Other Statistics.

The biennial analysis of clerical salaries, *Clerical Salaries Analysis*, 1952, has been published by the Office Management Association (price 25*s*.). It contains details of the medians and quartile ranges of salary for clerical workers in each of the six Job Grades which are defined in a schedule appendix to the Report. These grades range from messengers and the simplest clerical work to supervisors of sections and certain specialised work. The particulars are further analysed according to areas and industries and according to sex. For the lower grades separate information is given for younger and older employees. The figures, therefore, provide a useful standard with which employers can compare their own scales of pay, and the foreword to the report points out that it is noticeable that with each succeeding analysis the salary levels of different organizations have become closer together. Apart from the valuable analysis of current salaries, however, the five analyses so far published throw some light on the movement of clerical salaries over the last ten years. A strict comparison is invalidated by the fact that the figures do not cover the same establishments at each date, and because the shortage of office boys and junior clerks has led to the employment of older workers on simpler work. Nevertheless it is significant that the simplest clerical work costs 56*s*. 9*d*. a week for a male and 48*s*. 9*d*. for a female in 1952, compared with 23*s*. 6*d*. and 22*s*. 2*d*. in 1942.

The male supervisor now receives 225*s*. 11*d*. compared with 153*s*. 8*d*. in 1942, while the female supervisor receives 162*s*. compared with 94*s*. 6*d*. All these figures are the medians. In the four senior grades, in which the substitution of older for younger workers has probably had little effect, the rise in the median rates of pay in the last two years appears to have been a little greater than the increases in retail prices and in the rates of pay of manual workers.

Whatever the precise constitutional position of *Southern Rhodesia*, the material in the recently published 1952 edition of the *Official Yearbook* is of "Dominion status" quality. Publication policy in Southern Rhodesia does not, however, appear to envisage such frequent issues as we have of the corresponding volumes prepared by Canada, Australia, New Zealand, and South Africa. Southern Rhodesia takes a population census every five years and the Africans (other than those in employment), who are excluded from this operation, have been the subject of a full scale sample inquiry which has given, for the first time, information on birth and death rates and the rate of natural increase. In addition to a wealth of information on primary production, including the result of a second sample inquiry into the agricultural output of Africans, the Year-book contains a very full section on secondary industries, based on an annual census of production. Towards the end of the volume the economy of Southern Rhodesia is summed up in a chapter on "National Income and Social Accounts" which shows that the value of income generated in the money economy almost doubled between 1946 and 1950. Price increases can account for only a small proportion of this growth, and it is noteworthy that "home investment" in 1949 and 1950 reached the extremely high level of approximately 40 per cent. of the net national income.

It has probably not been easy in the past for a resident in Lagos to obtain the latest statistical material prepared by the Government of Nigeria nor for somebody in Kingston to do the same for Jamaica, but on quite a different plane have been the difficulties of someone in Europe or

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America trying to find up-to-date statistical material on some aspect of Colonial development, or even the basic statistical series for a regional group of Colonial territories. The minimum qualifications for such a task were probably those of a good research assistant. The Colonial Office has now brought this state of affairs to an end by publishing a *Digest of Colonial Statistics*. The first number, for March/April, was issued in early May, and No. 2, for May/June, in early July. The scope of the new Digest reflects the present early stage in the growth of the statistical services in most Colonial territories, e.g., employment statistics are not shown and the information on industrial production is particularly inadequate. Nevertheless many of the existing data become available for the first time and this is an enormous advance. The Digest, it is hoped, will grow steadily and the authors, with a commendable regard for the needs of the users of the volume, have asked for suggestions on desirable forms of expansion.

U.N. Statistical Papers. Series C, No. 5.—This fifth number in a series of periodical reports, the purpose of which is to assist those interested in the application of modern sampling techniques, summarizes surveys in eighteen countries and in a wide variety of fields—industrial, demographic, medical, agricultural, etc. Since it is the techniques rather than the findings which are reported and the sources of fuller information are always indicated, this series can be recommended to all statisticians who wish to keep in touch with current developments of sampling in countries and fields other than their own.

In the *U.N. Statistical Papers, Series H.* there will be published twice each year the latest available national income statistics for as many countries as possible. No 1 covers the years 1938-1950, all figures being at factor cost. For certain countries, income totals adjusted to permit international comparisons are also tabulated in this issue. Index numbers of national and *per capita* income in constant prices, the composition of national income by industrial origin, distributive shares and expenditure categories form the material of other tables. Full explanatory notes accompany each table.

Population Bulletin, No. 1 (December, 1951), published by the Population Division of the United Nations, is the first issue of a publication (to appear at irregular intervals) intended to contain brief articles on population which by their nature do not require separate publication in the series *Population Studies*. Most of the articles are to be contributed (anonymously) by members of the U.N. staff, but articles by others may be included. The present number contains one such article by Dr. Lorimer, the American demographer, on the dynamics of age structure in a population with high fertility and mortality. The three other articles deal with the past and future growth of world population, on international migrations in the Far East and on the quantitative aspects of the ageing of western populations. The articles are all of high standard and well documented. This bulletin will form a valuable complement to the numerous studies already in course of publication by the Population Division.

World Health Organisation: Expert Committee on Health Statistics, Third Report (W.H.O. Technical Report Series No. 53, Geneva, 1952). This meeting held in Geneva in November 1951 was primarily a Conference on Morbidity Statistics. The Chief Statistician (Medical) of the General Register Office was rapporteur (Dr. Logan). The Committee adopted a list of types of morbidity statistics (sickness surveys, census enumerations, hospital records, insurance records, records of notifiable diseases, accidents etc.—to name the principal sources) indicating the population coverage, the morbidity coverage, the uses to which they could be put and the groups of countries to which each type would be applicable. It recommended that the national committees on vital and health statistics study and report on these subjects, as well as on the terms currently used and on the methods of measurement of morbidity, to an international conference of such committees proposed for 1953. The Committee also received the report of the year's work done by the Centre for the Classification of Diseases set up in January, 1951, by W.H.O. in co-operation with the General Register Office (England and Wales), of which Dr. P. Stocks is the chief.

World Health Organisation: Annual Epidemological and Vital Statistics 1947–1949. *Part I: Vital Statistics and Causes of Death.* (Geneva, 1952.). This large volume of about 750 pages, completing and extending a similar one issued in 1951 for the years 1939–1946, gives for all

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countries for which information is available the principal vital statistics for the years 1946–1949 (in spite of the title) of births, deaths, marriages, both actual numbers and rates, and comparative figures for 1936–1938 (annual average). The bulk of the volume (over half) is devoted to the statistics of causes of death for some forty countries both by sex and by age groups. The list of causes is that of the International abridged list of 1938, the revised 1948 edition of the list not coming into force until January 1st, 1950. A final section gives for these countries a summary of life tables for the last 20 years (mortality rates, survivors, and expectation of life). A brief foreword and introduction indicate the reservations to be attached to the figure and give some general comments on the data.

The World Economic Report 1950–51 (140 *pp* $1.50) recently issued is the fourth in the series issued by United Nations. This issue is confined largely (in Part I) to an analysis of changes in the economic situation in these years in three broad groups of countries "private enterprise economies", "centrally planned economies", and "underdeveloped economies" and (in Part II) to an analysis of changes in international trade and payments with special reference to the raw materials boom of 1950/51, the balance of payments of U.S.A., Western Europe and Japan, and the trade of the centrally planned economies. Wherever possible the analysis is presented in terms of national income and its major components. Detailed analyses of trends in production are provided, this year, in a separate supplement *Recent Changes in Production* (120 pp., $1.00). It is estimated that world industrial output (mines and manufactures) increased by 12 per cent. from 1950 to 1951, fuel and power production by about 12 per cent.; the harvest of food crops increased, it is estimated, by 3 per cent. from 1949/50 to 1950/1951. As in the previous year, the *Summary of Recent Economic Developments in Africa* (49 pp., $0.50) and the *Summary of Recent Economic Developments in the Middle East* (99 pp., $1.00) are treated in separate supplements. The former deals specially with public investment and technical assistance, and the latter chiefly with the petroleum industry and foreign trade of the region. This report with its three supplements and its wealth of statistical tables, though considerably reduced in volume compared with its predecessor, succeeds admirably in focusing attention on world economic conditions and trends. The chapters on the five-year plans of the countries of Eastern Europe and of China, and on the trade of these centrally planned economies are of special interest.

CURRENT NOTES

Recognition of priority.—Professor J. Neyman of the University of California writes: I am obliged to Dr. Donovan J. Thompson of the Statistical Laboratory, Iowa State College, Ames, Iowa, for calling my attention to the article of A. A. Tschuprow, "On the mathematical expectation of the moments of frequency distributions in the case of correlated observations" published in *Metron*, Vol. 2, No. 4 (1923), pp. 646–683, which contains some results refound by me and published, without reference to Tschuprow, in 1933.

The results in question are the general formula for the variance of the estimate of a mean in stratified sampling and the formula determining the optimum stratification of the sample. These formulae appeared first in a Polish booklet *An Outline of the Theory and Practice of Representative Method, Applied in Social Research* published in 1933 by the Warsaw Institute of Social Problems. Later on they were republished in English in the *Journal of the Royal Statistical Society*, Vol. 97 (1934), pp. 558–625. Finally, the same formulae, again without a reference to Professor Tschuprow, were given in the second edition of my book, *Lectures and Conferences on Mathematical Statistics and Probability*, Washington, D.C., 1952.

The purpose of this note is, then, to recognize the priority of Professor Tschuprow, to express my regret for overlooking his results and to thank Dr. Thompson for calling my attention to the oversight.

Volume II (1935) of the *Supplement* to the *Journal* (the original title of the publications now called *Series B*), which has been out of stock for many years has been reprinted and is available at 25*s*. A complete set of the series may thus now be obtained. Prices will be sent on application to the Secretary of the Society.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

Agricultural Economics Society, Journal of Proceedings—

June 1952—Problems of farm classification: *P. M. Scola.* An American looks at farm management research in Britain: *K. T. Wright.* A survey of West Highland agriculture: *G. G. Hayes.* Agricultural economics and farm management advisory work: *W. E. Heath.* Some suggestions for determining the economic use of machinery: *M. Mathieson.*

Annals of Eugenics—

May 1952—Body weight at different ages and heights: *W. F. F. Kemsley.* Blood groups in Jews from the Yemen: *A. Brzezinski, J. Gurevitch, D. Hermoni* and *G. Mundel.* A statistical study of human twinning: *N. McArthur.* Simple tests for bimodality and bitangentiality: *J. B. S. Haldane.*

British Journal of Psychology (Statistical Section)—

June 1952—On the adjustment of Terman-Merrill I.Q.'s to secure comparability at different ages: *J. A. Fraser Roberts* and *M. A. Mellone.* An empirical study of political, religious and social attitudes: *M. Sanal.* The prediction of a complex aptitude: *C. Wrigley.* A refactorization of the Burt-Pearson matrix with the Ordvac electronic computer: *C. Wrigley* and *J. O. Neuhaus.* Tests of significance in factor analysis: *C. Burt.*

British Journal of Social Medicine—

April 1952—Statistical theory of prophylactic and therapeutic trials, I: *L. Hogben* and *R. Wrighton.* The health of an urban community: *L. Stein* and *S. A. Sklaroff.* Observations on all births (23,970) in Birmingham, 1947: *J. R. Gibson* and *T. McKeown.*

Operational Research Quarterly—

March 1952—Marshalling and queueing.

Oxford Economic Papers—

July 1952—The finance of investment: *B. Tew.* Some notes on public company balance-sheets and the ascertainment of the liquid position: *F. Stones.* Pensions and rising prices: *V. S. Garibian* and *P. J. D. Wiles.* Wage stabilization in the United States: *B. C. Roberts.* Some economic aspects of the wool trade: *P. Nettl.*

Oxford University Institute of Statistics, Bulletin—

June 1952—A "human needs" diet in April, 1952: *T. Schulz.* Investment in Britain and the United States: *T. Balogh.* The number of incomes and the effect of the budget: *J. Mitchell.*

Population Studies—

July 1952—Recent developments in French immigration policy: *C. Watson.* New Zealand and Asiatic migration: *H. Bernardelli.* Estimating by sample the size and age-sex structure of a population: *H. Silcock.* The population controversy in eighteenth century England: *D. V. Glass.* Some observations on modern Malthusianism: *K. Smith.* Infantile mortality rates: *S. W. Caffin.*

Review of Economic Studies—

Vol. XIX (3), 1951–52—Qualities, prices and budget enquiries: *H. Theil.* Management and size of the firm: *N. S. Ross.* Compensated changes in quantities and qualities consumed: *H. S. Houthakker.*

Royal Society of Edinburgh, Proceedings, Section B—

Vol. LXIV, Part IV—Quantitative evolution. XXI. Some correlations in the present results of production rates: *J. Small.* Estimation of fertile and infertile marriages and

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size of family: *C. M. Burns.* Sexual maturity in brown leghorns. The interactions of genotype and environment: *R. Osborne.* On the sampling variance of heritability estimates derived from variance analysis: *R. Osborne* and *W. S. B. Paterson.*

AUSTRALIA AND NEW ZEALAND

Economic Record—

May 1952—The degree of monopoly power: *R. Hieser.* The pre-war demand for wool: *F. B. Horner.* Labour turnover in butter factories in New Zealand: *C. Vautier.* Insurance in the Australian balance of payments: *S. J. Lengyel.* The size of towns: *E. P. Neale.*

INDIA—

Sankhyā—

December 1951—Dynamic systems of the recursive type—economic and statistical aspects: *H. O. A. Wold.* The applicability of large sample tests for moving average and auto-regressive schemes to series of short length—an experimental study. Part 1: Moving average: *A. Matthai* and *M. B. Kanan*; Part 2: Autoregressive series: *S. R. Rao* and *R. K. Som*; Part 3: The discriminant function approach in the classification of time series (part III of statistical inference applied to classificatory problems): *C. R. Rao.* On the estimation of parameters in a recursive system: *A. C. Das.* Bias in estimation of serial correlation co-efficients: *A. S. R. Sastry.* Some moments of moment-statistics and their use in tests of significance in auto-correlated series: *A. S. R. Sastry.* Elasticities of demand for certain Indian imports and exports: *V. N. Murti* and *V. K. Sastri.* Balance between income and leisure: *M. V. Jambunathan.* The use of commercial punched card machines for statistical analysis, with special reference to time series problems: *A. Matthai.* On simple difference sets: *T. A. Evans* and *H. B. Mann.* Bounds on the distribution of chi-square: *S. A. Vora.* On the limit points of relative frequencies: *D. Basu.*

UNION OF SOUTH AFRICA—

South African Journal of Economics—

June 1952—The development of the iron and steel industry in South Africa: *F. Meyer.*

UNITED STATES—

American Academy of Political and Social Science, Annals—

May 1952—The future of our natural resources. (Whole number.)

American Economic Review—

May 1952—Papers and proceedings of the Sixty-fourth Annual Meeting of the American Economic Association.

June 1952—The current state of profit theory: *R. M. Davis.* Spatial price equilibrium and linear programming: *P. Samuelson.* Our changed population outlook: *J. S. Davis.* Monetary policy and the Treasury bill market: *D. A. Alhadeff.* A sugar policy for the United States: *B. C. Swerling.*

American Statistical Association, Journal—

June 1952—An analysis of some failure data: *D. J. Davis.* Classification and analysis of partially balanced incomplete block designs with two associate classes: *R. C. Bose* and *T. Shimamoto.* Replacing variables in correlation problems: *V. I. West.* Operating characteristics for tests of the stability of a normal population: *J. E. Walsh.* Multiple sampling of attributes: *D. S. Robson* and *A. J. King.* Estimating the product of several random variables: *G. D. Shellard.* Some principles of processing census and survey data: *R. B. Voight* and *M. Kriesberg.* Short-cut methods of estimating county population: *R. C. Schmitt.* Sampling surveys in Central Africa: *J. R. H. Shaul.* Factors in the accumulation of social statistics: *S. Fabricant.* Comparison of selected measures of ability of communities to bear tax burdens: *L. A. Thompson.* A critical evaluation of available agricultural statistics: *I. M. Lee.* Prepaid medical care as a source of morbidity data: *N. R. Deardorff.* Some cases in which Yates's correction should not be applied: *E. L. Crow.*

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Annals of Mathematical Statistics—

March 1952—Abraham Wald, 1902–1950: *J. Wolfowitz*. The formative years of Abraham Wald and his work in geometry: *K. Menger*. Abraham Wald's contributions to econometrics: *G. Tintner*. The publications of Abraham Wald. On the power function of tests of randomness based on runs up and down: *H. Levene*. On the structure of balanced incomplete block designs: *W. S. Connor, Jr.* Formulas for the group sequential sampling of attributes: *H. L. Jones*. An application theory to multivariate analysis: *S. Kullnack*. Corrections for non-normality in the use of the two-sample *t*- and *F*- tests at high significance levels: *R. A. Bradley*. A Bayes approach to a quality control model: *M. A. Girschick* and *H. Rubin*. Testing a straggler mean in a two-way classification using the range: *J. Moshman*. Note on Wilcoxon's two-sample test when ties are present: *J. Hemelrijk*. Correction to "On certain methods of estimating the linear structural relation": *J. Neyman* and *E. L. Scott*.

June 1952—The large-sample power of tests based on permutations of observations: *W. Hoeffding*. Asymptotic theory of certain "goodness of fit" criteria based on stochastic processes: *T. W. Anderson* and *D. A. Darling*. A generalization of the Neyman-Pearson fundamental lemma: *H. Chernoff* and *H. Scheffé*. Maximum likelihood estimation in truncated samples: *M. Halperin*. On the comparison of several experimental categories with a control: *E. Paulson*. On the most economical sample size for controlling the mean of a population: *H. Weiler*. Optimum allocation in linear regression theory: *G. Elfving*. On the distribution of two random matrices used in classification procedures: *R. Sitgreaves*. The distribution of the number of isolates in a social group: *L. Katz*. Justification and extension of Doob's heuristic approach to the Kolomogorov-Smirnov theorems: *M. D. Donsker*. A note on the convolution of uniform distributions: *E. G. Olds*. A lower bound for a probability moment of any absolutely continuous distribution with finite variance: *S. Moriguti*. Uniformity field trials when differences in fertility levels of subplots are not included in experimental error: *G. A. Baker*. A generalization of a theorem due to Macneish: *K. A. Bush*. On a limiting case for the distribution of exceedances, with an application to life-testing: *L. B. Harris*. Correction to "The sampling distribution of the ratio of two ranges from independent samples": *R. F. Link*.

Bell System Technical Journal—

July 1952—Network synthesis using Tchebycheff polynomial series: *S. Darlington*. Efficient coding: *B. M. Oliver*. Statistics of television signals: *E. R. Kretzmer*. Experiments with linear prediction in television: *C. W. Harrison*.

Biometrics—

March 1952—Analysis of factorial arrangements when the data are proportions: *G. V. Dyke* and *H. D. Patterson*. The estimation of response-time distributions. I. Fundamental concepts and general methods: *M. R. Sampford*. The use of ranks in a test of significance for comparing two treatments: *C. White*. Variances between means when there are two missing values in randomized block designs: *W. D. Baten*. On the construction of tables for moving-average interpolation: *W. R. Thompson* and *C. S. Weil*. Errors and variations in white-cell counts: *A. C. Chamberlain* and *F. M. Turner*. On the dual of some balanced incomplete block designs: *S. S. Shrikhande*. Latinized reactangular lattices: *B. Harshbarger* and *L. L. Davis*.

June 1952—A method of enumeration of individual marrow elements for research purposes: *J. Sharp*, *E. L. Feinmann* and *J. F. Wilkinson*. The problem of birth ranks: *E. S. Keeping*. A comparison of Litchfield-Wilcoxon and Bliss estimates: *F. F. Eisenberg*. Analysis of partially balanced incomplete block designs illustrated on the simple square and rectangular lattices: *K. R. Nair*. The computation of sums of squares and products on a desk calculator: *J. M. Hammersley*.

Econometrica—

July 1952—Habit persistence and lags in consumer behaviour: *T. M. Brown*. Four alternative policies to restore balance of payments equilibrium : *J. Tinbergen*. Les elasticités de la demande relative aux biens de consommation et aux groupes de biens: *R. Roy*. A general location principle of an optimum space-economy: *W. Isard*. Safety first and the holding of assets: *A. D. Roy*. The inventory problem: II. Case of unknown distributions of demand: *A. Dvoretzky*, *J. Kiefer* and *J. Wolfowitz*. Concepts, sources, and methods of United States national income accounts: *R. Ruggles*.

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Industrial Quality Control—

July 1952—An application of statistical quality control techniques to specification requirements: *C. L. Matz.* Importance of quality control in industry: *R. R. Rausch.* Use of random numbers: *F. Proschan.* Tables for constructing and for computing the operating characteristics of single-sampling plans: *J. M. Cameron.*

Journal of Political Economy—

June 1952—Intelligence and occupational mobility: *C. A. Anderson, J. C. Brown* and *M. J. Bowman.*

Milbank Memorial Fund Quarterly—

July 1952—Change with age in susceptibility to minor respiratory illness: *J. Downes.* Incidence of pneumonia in two communities in New York State: *D. Tucher.*

Psychometrika—

March 1952—The selective efficiency of a test battery: *H. S. Sichel.* Factor analysis of the Army Air Forces Sheppard Field Battery of Experimental Aptitude Tests: *J. P. Guilford, B. Fruchter* and *S. Z. Wayne.* The effect of difficulty and chance success on item-test correlations and test reliability: *L. B. Plumlee.* A factor analysis of women's measurements taken for garment and pattern construction: *H. Heath.*

Quarterly Journal of Economics—

May 1952—A close-up of the Soviet fourth five-year plan: *N. Jasny.* The essential properties of interest and money: *A. P. Lerner.* Program patterns and preferences, and the workability of competition in radio broadcasting: *P. O. Steiner.*

Review of Economics and Statistics—

May 1952—The interindustry relations study for 1947: *W. D. Evans* and *M. Hoffenberg.* Manufacturing progress functions: *W. Z. Hirsch.* Four comments on "The measurement of industrial concentration" with a rejoinder by Professor Adelman: *C. D. Edwards, G. W. Stocking, E. B. George, A. A. Berle, Jr.,* and *M. A. Adelman.* Investment-in-self: *J. O. Kamm.*

BELGIUM—

Bulletin de l'Institut de Recherches Économiques et Sociales—

June 1952—La conjoncture économique de la Belgique: *M. Woitrin.*

FRANCE—

Population—

April–June 1952—Le problème et la politique démographiques au Japon: *A. Okasaki.* Une évaluation du nombre des alcooliques en France depuis 1945: *S. Ledermann.* Effets de la consanguinité et de l'endogamie. Une enquête en Morbihan et Loir-et-Cher: *J. Sutter* and *L. Tabah.* Mesure de la fréquence des divorces: *L. Henry.*

Revue d'Économie Politique—

March–April 1952—Le sous-développement et ses problèmes: *G. Leduc.* Les difficultés d'élaboration d'une théorie générale de la répartition: *M. Capet.*

May–August 1952—La France économique en 1951. (Whole number.)

GERMANY—

Allgemeines Statistisches Archiv—

Vol. 36, Part 1—Meinungsforschung: *G. H. Horn.* Methodisches zur Statistik der Patienten im Krankenhaus: *E. Meier.* Der Einsatz der technischen Statistik in Industrie und Wirtschaft: *H. J. Henning.* Neue Zählmaschinen: *A. A. Tooms.* Repräsentativerhebungen zur kurzfristigen Beobachtung von Einkommensverteilung und Einkommensverwendung im Ausland: *H. Schmucker.*

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Weltwirtschaftliches Archiv—

Vol. 68, Part 2—Die Politik des Federal Reserve Systems 1945–1951: *C. R. Whittlesey.* Handelspolitik zwischen Bilateralismus und Multilateralismus: *H. Möller.*

HOLLAND—

Statistica—

Vol. 5, Nos. 5–6—De natuur als tegenspeler: *D. van Dantzig.* Toepassing van de bezettinstheorie op een coderingsvraagstuk: *P. de Wolff.* Parametrische en parametervrije methoden en hun toepassingen: *J. Hemelrijk.* De toets van Wilcoxon: *H. R. van der Vaart* and *D. van Dantzig.*

ITALY—

Giornale degli Economisti e Annali di Economia—

January–February 1952—I costi di distribuzione: *G. Demaria.* Riflessioni sullo sviluppo economico dei paesi arretrati e, in particolare, sugli effetti di una redistribuzione del reddito: *V. Marrama.* Rischio crescente ed ingresso di capitale nello sviluppo economico: *I. Gasparini.*

Statistica—

April–June 1952—A proposito di riordinamento dei servizi statistici: *P. Fortunati.* Rilevazioni sul valore aggiunto e sugli investimenti: *B. Barberi.* Ricerche sperimentali sulla distribuzione dei consumi del gas: *A. Bellettini.* Sull'organizzazione della statistica ufficiale sovietica: *S. Somogyi.*

SWEDEN—

Acta Agriculturae—

Vol. II, Part 1—Studies on udder evacuation in dairy cows. I. The rise in fat percentage during milking: *I. Johansson, N. Korkman* and *N. J. Nelson.* II. The amount and composition of residual milk after normal milkage: *I. Johansson.*

SWITZERLAND—

Schweizerische Zeitschrift für Volkswirtschaft und Statistik—

April 1952—Theorie der Börsenkursbildung: *L. A. Hahn.* Bemerkungen zur Verstädterung: *A. Schwarz.*

INTERNATIONAL—

International Labour Review—

August 1952—The adjustment of wages to changes in the cost of living: *B. Zoeteweig.*

Revue de l'Institut International de Statistique—

Vol. 19, No. 3—The twenty-seventh session, New Delhi, December 16–18, 1951: *S. A. Rice.* Census taking in Canada: *H. Marshall.* Sur une méthode de double échantillonnage pour estimer la moyenne d'une population Laplacienne stratifiée: *J. Putter.*

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LIST OF ADDITIONS TO THE LIBRARY

Since the issue of Part III, 1952, the Society has received the publications enumerated below.

I.—OFFICIAL PUBLICATIONS

(a) United Kingdom

Commonwealth Relations Office. A guide to the India Office Library; by S. C. Sutton . . . London, H.M.S.O., 1952. iv, 62 pp. 8½″. 6*s.* 6*d.*

General Register Office. Census 1951. Classification of industries. London, H.M.S.O., 1952. vi, 82 pp. 13″. 8*s.* 6*d.*

General Register Office and General Registry Office, Scotland. Census 1951. Great Britain one per cent sample tables . . . Part I. Ages and marital condition, occupations, industries, housing of private households. London, H.M.S.O., 1952. xix, 159 pp. map. 13″. 17*s.* 6*d.*

Medical Research Council. Employment problems of disabled youth in Glasgow; by T. Ferguson, A. N. MacPhail and M. I. McVean. London, H.M.S.O., 1952. vi, 66 pp. 9½″. 3*s.* (Memorandum, 28.)

Metropolitan Police. Metropolitan Police District: a statistical analysis of road accidents in 1951. London, Commissioner of Police, 1952. [2] 28, [6] pp. + maps, diagrs. 12¾″.

Ministry of Agriculture and Fisheries. American agriculture, its background and its lessons; by A. N. Duckham . . . London, H.M.S.O., 1952. iv, 78 pp. maps. 9½″. 2*s.* 6*d.*

Ministry of Works. The lighting of office buildings; by the Lighting Committee of the Building Research Board of the Department of Scientific and Industrial Research. London, H.M.S.O., 1952. 88 pp. 9½″. 3*s.* 6*d.* (Post-War Building Studies, 30.)

Monopolies and Restrictive Practices Commission. Report on the supply of cast iron rainwater goods. 1951. v, 132 pp. 9½″. 3*s.* 6*d.* Report on the supply of dental goods. 1950. v, 138 pp. 9½″. 3*s.* 6*d.* Report on the supply of insulated electric wires and cables. 1952. iv, 170 pp. 9½″. 5*s.* London, H.M.S.O.

Northern Ireland. Registrar General. Census of Northern Ireland 1951. Advance statement of population of each county, county and municipal borough, urban and rural district, and the wards of county boroughs. Belfast, 1951. 6 pp. typewritten. 13″.

Scotland. General Registry Office. Census 1951. Report on the fifteenth census of Scotland. Volume I. Part I. City of Edinburgh. Edinburgh, H.M.S.O., 1952. 47 pp. 13″. 7*s.* 6*d.*

Scottish Home Department. Report of the Committee on Scottish financial and trade statistics. Edinburgh, H.M.S.O., 1952. 92 pp. 9½″. 3*s.* Cmd. 8609.

Scottish sea fisheries statistical tables for 1939–48. Edinburgh, H.M.S.O., 1952. 76 pp. 13″. 4*s.* 6*d.*

Social Survey. Depopulation and rural life in the Solway Counties; by Bertram Hutchinson: the first report of an inquiry for the Department of Health for Scotland into the causes of rural depopulation, and designed to provide social data necessary for rural planning. 1949. iv, 110 pp. 12¾″.

The depopulation and rural life in the Tweed Valley . . . The second report of an inquiry . . . 1949. ii, 60 pp. 13″.

Depopulation and rural life in Aberdeen and Banff . . . The third report of an inquiry . . . 1949. 63 pp. 13″.

Depopulation and rural life in Scotland; by Bertram Hutchinson: a summary report of three inquiries for the Department of Health for Scotland in parts of rural Scotland as to the causes of rural depopulation. 1949. ii, 36 pp. 13″.

A forecast of effects of economies in London telephone directory services; by D. L. Lamberth. 1951. iii, 26 pp. 13″.

"Parliament past and present": exhibition at Westminster Palace, 1951; by Harold Orlansky. 1951. i, 43 pp. 13½″. London, Central Office of Information.

Treasury. Report of the Committee on the organization, structure and renumeration of the professional accountant class in the Civil Service. London, H.M.S.O., 1952. 22 pp. 9½″. 1*s.*

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(b) Other National and International Publications

Argentina

Servicio Estadistico Nacional. IV censo general de la nacion, 1947. Resultados generales del censo de poblacion. Buenos Aires, 1951. 40 pp. 10½″. (Informe D.1.)

Australia

Conference of British Commonwealth Statisticians, 1951, held at Canberra, Australia, from 12th–23rd November, 1951. Report of proceedings. Canberra, Government Printer, [1952]. 53 pp. 9½″.

Ceylon

Central Bank of Ceylon. Annual report of the monetary board to the Minister of Finance. Colombo, 1951. iii, 35 pp. 9¾″.

Cuba

Junta Nacional de Economia. Programma nacional de accion economica. La Habana, 1951. xxviii, 239 pp. 8¾″. (*Estud. Invest. Econ.* 5.)

Politica economica de emergencia. La Habana, 1951. xiv, 194 pp. 8¾″. (*Estud. Invest. Econ.* 10.)

Resumen del informe sobre Cuba. Estudios y recomendaciones de una misión economica y tecnica organizada por el Banco Internacional de Reconstrucción y Fomento en colaboración con el Gobierno de Cuba en el 1950; Francis Adams Truslow, Jefe de la Mision. Banco Internacional de Reconstrucción y Fomento, Washington, D.C., 1951. La Habana, 1951. xvii, 42 pp. 8¼″. (*Estud. Invest. Econ.* 11.)

Honduras

Direccion General de Estadistica. Resumen general del censo de vivienda, levantado el 10 de julio de 1949. Tegucigalpa [n.d.] 246 pp. 8¼″.

New Zealand

Census and Statistics Department. Population census, 1945. Vol. V. Dependent children. 58 pp. 12*s.* 6*d.* Vol. VI. Religious professions. iii, 24 pp. 10*s.* Vol. X. Incomes. ii, 110 pp. 7*s.* 6*d.* Appendix C. Usual place of residence. 8 pp. 3*s.* 6*d.* Wellington, 1952. 4 vols. 12¼″.

Southern Rhodesia

Central African Statistical Office. Report on the 1950 demographic sample survey of the African population of Northern Rhodesia. Salisbury, 1952. iv, 43 pp. 13″.

United Nations

Department of Economic Affairs. World economic report 1950–51. New York, 1952 (London, H.M.S.O.). ix, 140 pp. 11″. 11*s.* (1952.II.C.4.)

Recent changes in production: supplement to World Economic Report, 1950–51. New York, 1952. v, 120 pp. 10¾″. 7*s.* 6*d.* (1952.II.C.1.)

Summary of recent economic developments in Africa: supplement to World Economic Report, 1950–51. New York, 1952. iv, 49 pp. 10¾″. 3*s.* 9*d.* (1952.II.C.2.)

Summary of recent economic developments in the Middle East: supplement to World Economic Report, 1950–51. New York, 1952. iv, 99 pp. 10¾″. 7*s.* 6*d.*. (1952. II.C.3.)

World Health Organization

Annual epidemiological and vital statistics 1947–1949. Part I. Vital statistics and causes of death. Prepared by the Division of Health Statistics. Geneva, 1952 (London, H.M.S.O.). 746 pp. 11″. 70*s.*

Comparability of statistics of causes of death according to the fifth and sixth revisions of the international list. Geneva, 1952 (London, H.M.S.O.). 2*s.* 9*d.* (*Supp. Bull. World Hlth. Org.* 4.)

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World Health Organization (*contd.*)

Expert Committee on Health Statistics. Third report, including second report of the subcommittee on the registration of cases of cancer as well as their statistical presentation. Geneva, 1952. (London, H.M.S.O.). 54 pp. 9½″. 2*s*. 9*d*. (World Hlth. Org. Tech. Rep. Ser. 53.)

II.—AUTHORS AND MISCELLANEOUS

Bowley (Sir Arthur). An elementary manual of statistics. 7th ed. London, MacDonald & Evans, 1952. ix, 297 pp. 8½″. 10*s*.

British Employers' Confederation, & Federation of British Industries. First International Conference of Manufacturers New York 1951 . . . London, 1951. vi, 39 pp. 9″. 1*s*. 2*d*.

Broide (Julio). La evolucion de los precios pecuarios Argentinos en el periodo 1830–1850. *Rev. Fac. Cienc. Econ.* (1951), Abril. 75 pp. 10¼″.

Cantor (Georg). Contributions to the founding of the theory of transfinite numbers . . . Translated . . . by Philip E. B. Jourdain . . . New York, Dover Publications, [1952]. ix, 211 pp. + front. 8″. $1.25.

Cattell (Raymond B.). Factor analysis: an introduction and manual for the psychologist and social scientist. New York, Harper, 1952 (London, Hamish Hamilton). xiii, 462 pp. 8¼″. 48*s*.

Daniels (Marc) & Hill (A. Bradford). Chemotherapy of pulmonary tuberculosis in young adults: an analysis of the combined results of three Medical Research Council trials. *Brit. Med. J.* (1952), **1**, 1162. 17 pp. 8½″.

Finney (D. J.). Graphical estimation of relative potency from quantal responses. *J. Pharmacol.* (1952), **104**, 440–444. 10″.

Hammersley (J. M.). The sums of products of the natural numbers. *Proc. Lond. Math. Soc.* (1951), **3**, 435–452. 9¼″.

Heyworth (Sir Geoffrey). The place of margarine in the economics of nutrition. London, Unilever, 1952. 16 pp. 8″.

Hickman (W. Braddock). Trends and cycles in corporate bond financing. New York, National Bureau of Economic Research, 1952. [x], 37 pp. 9″. $.75. (Financial Research Program. Occasionsl Paper 37.)

Hofsten (Erland v.). Price indexes and quality changes. Stockholm, Bokförlaget Forum, 1952 (London, Allen & Unwin). 136 pp. 9″.

Jambunathan (M. V.). The theory of linear estimation (including application to testing of hypothesis). Bangalore, India Book Company, 1951. vi, 83, [1] pp. 8¾″. *Rs*. 3.

Jennings (L. G.). United Kingdom imports of wood veneers 1920–1951 . . . *T.D.A. Quarterly* (1952), April. [4] pp. 11″.

Kantner (J. F.) & Whelpton (P. K.). Social and psychological factors affecting fertility. XVI. Fertility rates and fertility planning by character of migration. *Milbank Mem. Fd. Quart. Bull.* (1952), **30**, 152–187. 9″.

Kottler (F.). The distribution of particle sizes. I. The facts. II. The probability graphs. *J. Franklin Inst.* (1950), **250**, 339–441. 9½″.

Kriz (Miroslav A.). The price of gold. Princeton University, International Finance Section, 1952. 27 pp. 9″. (Essays in International Finance, 15.)

Low (Alexander). Growth of children: sixty-six boys and sixty-six girls each measured at three days, and at one, two, three, four and five years of age. University of Aberdeen, 1952. 64 pp. 13″. 10*s*.

Mainland (Donald). Elementary medical statistics: the principles of quantitative medicine. Philadelphia & London, Saunders, 1952. ix, 327 pp. 8½″. 25*s*.

Meade (James Edward). A geometry of international trade. London, Allen & Unwin, 1952. 112 pp. + diagrs. [12] pp. 8½″. 28*s*.

Milbank Memorial Fund. Approaches to problems of high fertility in agrarian societies: papers presented at the 1951 Annual Conference of the Milbank Memorial Fund. New York, 1952. 171 pp. 9″. $1.

Milne (William Edmund). Numerical calculus: approximations, interpolation, finite differences, numerical integration, and curve fitting. Princeton University Press, 1949 (London, Oxford University Press). x, 393 pp. 9″. 24*s*.

Office Management Association. Clerical salaries analysis 1952 (as at 1st March, 1952). London, 1952. 68 pp. + Clerical job grading schedule (folded inset). 9½″. 25*s*.

Pavlovsky (Georges). Quelques observations sur l'aspect économique du projet français d'unification des marchés agricoles européens. *Feuill. Inform. Oleic. Int.* (1951), **6**, 19 pp. 9½″.

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PRINCETON UNIVERSITY. STATISTICAL RESEARCH GROUP. Memorandum report. No. 17–24, 26, 27, 29–32, 38, 40, 41, 41a, 43–45. Princeton University. 21 papers, mostly by Prof. Tukey. 11″. Presented by Prof. Tukey.

ROBBINS (LIONEL). The theory of economic policy in English classical political economy. London, Macmillan, 1952. xii, 218 pp. 8½″. 15*s*.

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SHORT (THOMAS). A comparative history of the increase and decrease of mankind in England, and several countries abroad . . . [with Publicola's letters, taken from The Public Ledger and General Evening-Post]. London, 1767. viii, iv, 213 pp. 9½″.

TIPPETT (L. H. C.). The methods of statistics. 4th ed. London, Williams & Norgate, 1952. 395 pp. 8½″. 38*s*.

TUKEY (JOHN WILDER), AND OTHERS. [Collected papers 1941–1951: offprints by J. W. Tukey and associates.] 30 offprints in 1 vol. 10″. Presented by Prof. Tukey.

VAN DER REYDEN (D.). A simple statistical signifance test. *Rhod. Agric. J.* (1952), **49**, 96–104. 9½″.

World list of scientific periodicals published in the years 1900–1950. 3rd ed. . . . London, Butterworth, 1952. xvii, 1058 pp. 10½″. 252*s*.

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REGISTRATION OF THE UNITED KINGDOM

No. I.—ENGLAND AND WALES

BIRTHS, DEATHS *and* MARRIAGES *registered in the Calendar years* 1947–1951 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living. (Deaths under* 1 *year of age; rate per* 1,000 *related Live Births. Stillbirths per* 1,000 *births.)*

Years	1947		1948		1949		1950[3]		1951†	
Estimated Mid-year Popln. in thousands‡	43,050		43,502		43,785		43,830		43,800§	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live Births	886,820	*20·6*	776,971	*17·9*	731,172	*16·7*	691,760	*15·8*	679,497	*15·5*
Stillbirths	21,916	*24*	18,469	*23*	16,977	*23*	16,055	*23*	15,949	*23*
Deaths[1]	517,615	*12·0*	469,898	*10·8*	510,736	*11·7*	510,301	*11·6*	548,918	*12·5*
Marriages	401,210	*9·3*	396,891	*9·1*	375,041	*8·6*	358,490	*8·2*	359,652	*8·2*
Infant Mortality	36,849	*41*	26,766	*34*	23,882	*32*	20,817	*30*	20,103	*30*
Effective reproductive rate[2]	*1·205*		*1·070*		*1·023*		*0·986*		*0·97*	
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–Mar.	241,530	*22·8*	202,047	*18·7*	186,611	*17·3*	180,130	*16·7*	176,299	*16·3*
Apr.–June	235,196	*21·9*	203,593	*18·8*	192,038	*17·6*	181,343	*16·6*	180,958	*16·6*
July–Sept.	216,508	*20·0*	191,858	*17·5*	183,221	*16·6*	170,087	*15·4*	168,028	*15·2*
Oct.–Dec.	193,586	*17·8*	179,473	*16·4*	169,302	*15·3*	160,200	*14·5*	154,212	*14·0*
	Stillbirths									
Jan.–Mar.	6,347	*26*	5,045	*24*	4,446	*23*	4,238	*23*	4,259	*24*
Apr.–June	5,831	*24*	4,746	*23*	4,496	*23*	4,172	*23*	4,156	*23*
July–Sept.	5,073	*23*	4,447	*23*	4,118	*22*	3,919	*23*	3,727	*22*
Oct.–Dec.	4,665	*24*	4,231	*23*	3,917	*23*	3,726	*23*	3,807	*24*
	Deaths[1] (excluding Stillbirths)									
Jan.–Mar.	181,736	*17·1*	132,628	*12·3*	161,265	*14·9*	151,284	*14·0*	205,771	*19·1*
Apr.–June	118,015	*11·0*	110,257	*10·2*	119,972	*11·0*	120,791	*11·1*	121,298	*11·1*
July–Sept.	97,099	*8·9*	101,548	*9·3*	101,190	*9·2*	102,867	*9·3*	100,090	*9·1*
Oct.–Dec.	120,765	*11·1*	125,465	*11·5*	128,309	*11·6*	135,359	*12·3*	121,759	*11·0*
	Marriages									
Jan.–Mar.	75,241	*7·1*	95,443	*8·8*	81,774	*7·6*	86,900	*8·0*	109,187	*10·1*
Apr.–June	109,146	*10·2*	92,822	*8·6*	95,565	*8·8*	80,726	*7·4*	65,786	*6·0*
July–Sept.	119,426	*11·0*	123,157	*11·2*	114,405	*10·4*	114,828	*10·4*	111,173	*10·0*
Oct.–Dec.	97,397	*9·0*	85,469	*7·8*	83,297	*7·6*	76,036	*6·9*	73,506	*6·7*
	Infant Mortality									
Jan.–Mar.	12,561	*55*	8,387	*41*	7,532	*40*	6,575	*39*	6,530	*38*
Apr.–June	9,195	*40*	6,357	*31*	5,758	*30*	5,034	*29*	5,029	*29*
July–Sept.	7,141	*32*	5,514	*28*	4,915	*27*	4,176	*24*	3,998	*24*
Oct.–Dec.	7,952	*38*	6,508	*35*	5,677	*32*	5,032	*28*	4,546	*28*

* All rates are based on the estimated population as at the middle of the corresponding year.
† Provisional figures.
‡ For 1947–1949, total populations, i.e., including members of Armed Forces stationed at home and abroad. For 1950–1951, home populations, i.e., including members of Armed Forces stationed within England and Wales.
§ Examination in the light of the new Census data indicated that the estimates of preceding years had become inflated and that but for this a population increase of some 46,000 would have been recorded for the year 1950/51 instead of the decline of 30,000 shown above.
[1] Including deaths of non-civilians registered in England and Wales.
[2] Based not upon current, but upon estimated future mortality.
[3] Final figures by courtesy of the Registrar-General for England and Wales.

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No. II.—SCOTLAND

BIRTHS, DEATHS *and* MARRIAGES *registered in the Calendar years* 1947–1951, *and in the Quarters of those years. Numbers, Annual and Quarterly Rates*, per* 1,000 *persons living. (Deaths under* 1 *year of age, rate per* 1,000 *Live Births; Stillbirths per* 1,000 *Births.)*

Years	1947		1948		1949		1950†		1951†	
Estimated mid-year Popln. in thousands‡	5,139		5,169		5,175		5,175		5,114	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live Births	113,147	*22·0*	100,344	*19·4*	95,674	*18·5*	92,530	*17·9*	90,635	*17·7*
Stillbirths	3,563	*31*	2,966	*29*	2,666	*27*	2,557	*27*	2,470	*27*
Deaths	66,200	*12·9*	60,979	*11·8*	63,488	*12·3*	63,996	*12·4*	65,778	*12·9*
Marriages	44,360	*8·6*	43,747	*8·5*	41,709	*8·1*	40,483	*7·8*	41,368	*8·1*
Infant Mortality ..	6,309	*56*	4,486	*45*	3,961	*41*	3,569	*39*	3,391	*37*
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–Mar.	30,479	*24·1*	25,324	*19·8*	24,230	*19·0*	23,542	*18·5*	23,625	*18·8*
Apr.–June	30,366	*23·7*	26,561	*20·7*	25,424	*19·7*	24,646	*19·1*	24,310	*19·1*
July–Sept.	27,028	*20·8*	24,389	*18·7*	23,324	*17·9*	22,498	*17·3*	21,931	*17·0*
Oct.–Dec.	25,274	*19·5*	24,070	*18·5*	22,696	*17·4*	21,844	*16·8*	20,769	*16·1*
	Stillbirths									
Jan.–Mar.	1,018	*32*	760	*29*	707	*28*	673	*28*	655	*27*
Apr.–June	913	*29*	775	*28*	710	*27*	659	*26*	656	*26*
July–Sept.	853	*31*	711	*28*	642	*27*	627	*27*	572	*25*
Oct.–Dec.	779	*30*	720	*29*	607	*26*	598	*27*	587	*27*
	Deaths (excluding Stillbirths)									
Jan.–Mar.	21,198	*16·8*	16,825	*13·1*	19,222	*15·1*	18,647	*14·7*	22,428	*17·8*
Apr.–June	15,653	*12·2*	14,698	*11·4*	15,274	*11·8*	14,986	*11·6*	15,442	*12·1*
July–Sept.	13,447	*10·4*	13,652	*10·5*	13,119	*10·1*	13,341	*10·2*	13,104	*10·2*
Oct.–Dec.	15,902	*12·3*	15,804	*12·2*	15,873	*12·2*	17,022	*13·1*	14,804	*11·5*
	Marriages									
Jan.–Mar.	9,497	*7·5*	9,966	*7·8*	10,638	*8·4*	11,118	*8·7*	11,560	*9·2*
Apr.–June	11,241	*8·8*	10,497	*8·2*	9,209	*7·1*	8,685	*6·7*	8,957	*7·0*
July–Sept.	12,747	*9·8*	13,518	*10·4*	12,787	*9·8*	11,854	*9·1*	12,051	*9·4*
Oct.–Dec.	10,875	*8·4*	9,766	*7·5*	9,075	*7·0*	8,826	*6·8*	8,800	*6·8*
	Infant Mortality									
Jan.–Mar.	1,915	*63*	1,303	*51*	1,225	*51*	1,080	*46*	1,088	*46*
Apr.–June	1,609	*53*	1,144	*43*	913	*36*	841	*34*	850	*35*
July–Sept.	1,353	*50*	972	*40*	823	*35*	737	*33*	698	*32*
Oct.–Dec.	1,432	*57*	1,067	*44*	1,000	*44*	911	*42*	755	*36*

* Death rates for 1947–49 are based on all deaths registered in Scotland, related to the total population.
" " 1950–51 " " " " " " home "
† Provisional figures.
‡ 1947–49 = Estimated mid-year total population.
1950 = " " home "

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No. III.—NORTHERN IRELAND

BIRTHS, DEATHS *and* MARRIAGES *registered in the Calendar years* 1947–1951 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates per* 1,000 *persons living. (Deaths under* 1 *year of age; rate per* 1,000 *Live Births.)*

Years	1947		1948		1949		1950[2]		1951[2]	
Estimated Mid-Year Popln. in thousands*	1,339		1,351		1,360		1,369		1,373	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live Births	31,254	*23·3*	29,532	*21·9*	29,106	*21·4*	28,794	*21·0*	28,477	*20·7*
Stillbirths[1]					Not registered					
Deaths	16,913	*12·6*	15,125	*11·2*	15,652	*11·5*	15,839	*11·6*	17,628	*12·8*
Marriages	9,517	*7·1*	9,360	*6·9*	9,216	*6·8*	9,072	*6·6*	9,414	*6·9*
Infant Mortality	1,658	*53*	1,347	*46*	1,317	*45*	1,165	*40*	1,173	*41*
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–Mar.	8,318	*24·9*	7,412	*22·1*	7,379	*21·8*	7,275	*21·3*	7,254	*21·2*
Apr.–June	8,539	*25·5*	8,030	*23·9*	7,764	*22·9*	7,725	*22·5*	7,769	*22·6*
July–Sept.	7,516	*22·4*	7,262	*21·5*	7,193	*21·2*	7,090	*20·7*	7,089	*20·5*
Oct.–Dec.	6,881	*20·5*	6,828	*20·2*	6,770	*19·9*	6,704	*19·5*	6,365	*18·4*
	Deaths‡ (excluding Stillbirths)									
Jan.–Mar.	5,902	*17·7*	4,313	*12·8*	4,758	*14·0*	4,552	*13·3*	6,971	*20·4*
Apr.–June	4,011	*12·0*	3,817	*11·4*	3,812	*11·2*	3,924	*11·4*	3,951	*11·5*
July–Sept.	3,276	*9·8*	3,323	*9·9*	3,228	*9·5*	3,222	*9·4*	3,211	*9·3*
Oct.–Dec.	3,724	*11·1*	3,672	*10·9*	3,854	*11·3*	4,141	*12·1*	3,495	*10·1*
	Marriages									
Jan.–Mar.	1,820	*5·5*	2,150	*6·4*	1,975	*5·8*	2,049	*6·0*	2,210	*6·5*
Apr.–June	2,517	*7·5*	2,158	*6·4*	2,287	*6·7*	2,075	*6·1*	1,958	*5·7*
July–Sept.	2,905	*8·6*	2,972	*8·8*	2,862	*8·4*	3,058	*8·9*	3,174	*9·0*
Oct.–Dec.	2,275	*6·8*	2,080	*6·2*	2,092	*6·1*	1,890	*5·5*	2,072	*5·9*
	Infant Mortality									
Jan.–Mar.	497	*60*	395	*53*	402	*55*	323	*44*	371	*51*
Apr.–June	442	*52*	352	*44*	297	*38*	284	*37*	292	*38*
July–Sept.	314	*42*	302	*41*	309	*43*	253	*36*	255	*36*
Oct.–Dec.	405	*59*	298	*44*	309	*46*	305	*45*	255	*40*

* For 1947–50 Rates are based on Civilian Population only; for 1951 they are based on "Home" Population.

‡ For 1947–50 civilian deaths only; for 1951, total deaths registered.

[1] Stillbirths are not registered in Northern Ireland. The birth of one living child and one stillborn, or one living child and two stillborn, is counted as one birth.

[2] Final figures by courtesy of the Registrar-General for Northern Ireland.

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No. IV.—EIRE

BIRTHS, DEATHS *and* MARRIAGES *registered in the Calendar years* 1947–1951 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living.* (*Deaths under* 1 *year of age, rate per* 1,000 *Live Births.*)

Years	1947		1948		1949		1950†		1951†	
Estimated Mid-year Popln. in thousands	2,974		2,985		2,981		2,955		2,959	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live Births	68,978	*23·2*	65,930	*22·0*	64,153	*21·5*	63,263	*21·3*	62,587	*21·2*
Stillbirths‡					Not registered					
Deaths	44,061	*14·8*	36,357	*12·2*	38,062	*12·7*	37,835	*12·7*	42,412	*14·3*
Marriages	16,290	*5·5*	16,115	*5·4*	16,009	*5·4*	16,173	*5·4*	15,860	*5·4*
Infant Mortality	4,687	*68*	3,313	*50*	3,415	*53*	2,866	*45*	2,840	*45*
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–Mar.	17,537	*23·6*	16,310	*21·9*	16,388	*21·9*	15,931	*21·2*	15,669	*20·9*
Apr.–June	18,946	*25·5*	18,143	*24·3*	16,774	*22·4*	16,936	*22·5*	16,908	*22·5*
July–Sept.	17,424	*23·4*	16,385	*22·0*	16,519	*22·1*	15,907	*21·3*	16,204	*21·9*
Oct.–Dec.	15,071	*20·3*	15,092	*20·2*	14,472	*19·4*	14,489	*19·3*	13,806	*18·7*
	Deaths (excluding Stillbirths)									
Jan.–Mar.	15,975	*21·5*	10,612	*14·2*	11,010	*14·7*	11,218	*15·0*	16,600	*22·1*
Apr.–June	11,161	*15·0*	9,333	*12·5*	9,920	*13·3*	9,724	*12·9*	10,220	*13·6*
July–Sept.	8,288	*11·1*	7,865	*10·5*	8,082	*10·8*	7,721	*10·3*	7,653	*10·3*
Oct.–Dec.	8,637	*11·6*	8,547	*11·5*	9,050	*12·1*	9.172	*12·2*	7,939	*10·7*
	Marriages									
Jan.–Mar.	3,769	*5·1*	3,568	*4·8*	3,622	*4·8*	3,457	*4·6*	3,327	*4·4*
Apr.–June	4,023	*5·4*	4,000	*5·4*	3,620	*4·8*	3.757	*5·0*	3,854	*5·2*
July–Sept.	4,899	*6·6*	5,011	*6·7*	5,186	*6·9*	5,600	*7·5*	5,482	*7·4*
Oct.–Dec.	3,599	*4·8*	3,536	*4·7*	3,581	*4·8*	3,359	*4·5*	3,197	*4·3*
	Infant Mortality									
Jan.–Mar.	1,639	*93*	1,059	*65*	928	*57*	937	*59*	916	*58*
Apr.–June	1,241	*66*	857	*47*	856	*51*	752	*44*	773	*46*
July–Sept.	832	*48*	649	*40*	749	*45*	585	*37*	589	*36*
Oct.–Dec.	975	*65*	748	*50*	882	*61*	592	*41*	562	*41*

* Rates are based on the total estimated population as at the middle of the corresponding year.
† Provisional figures.
‡ Stillbirths are not registered in Eire. The births of one living child and one stillborn, or of one living child and two stillborn, are counted as one birth.

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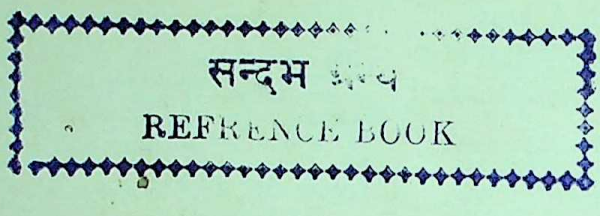

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